PROBLEMS OF WAR AND OF RECONSTRUCTION

EDITED BY

FRANCIS G. WICKWARE

THE STRATEGY OF MINERALS

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A STUDY OF THE MINERAL FACTOR IN THE WORLD POSITION OF AMERICA IN WAR AND IN PEACE

EDITED BY

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PREFACE

In the amount and variety of its current mineral output, as revealed by the statistician, and in the extent of its mineral wealth available for future use, as estimated by the geologist, America stands preëminent. These mineral resources contain possibilities of power; their utilization and their conservation present problems in strategy. The victories of peace, no less than those of war, come only with good generalship.

We Americans have been tardy in our recognition of how large a part Germany's avarice for the mineral wealth outside her boundaries played in bringing on the Great War and in directing its successive campaigns. The coal of Belgium, the iron of France, the oil of Rumania, and the manganese of Russia have been more than pawns in the game of war. Here in the United States of America we must not err again by being slow to recognize the strategic value of the mineral resources within our own borders. Strategy with a peaceful aim is no more a contradiction in terms than the purpose to enforce peace.

The words of a British statesman after the Crimean War have been quoted as laden with thought for the present time: "We have made a peace, but it is not the peace." Even in the midst of the Great War it was appropriate to set our faces towards the Great Peace. During the war increasing dependence was put upon the mineral resources of America, and military strategy utilized the material strength of the United States as well as its man power. After the war it becomes no less wise generalship to marshal all the forces of raw materials, of labor, of capital, and of engineering efficiency in a campaign that may assure America's full

participation in the peace of the world for which the Allies have fought.

Commercial geology will furnish an important chapter in the story of industrial development that will write itself in the decades immediately following the Great War. The essential *rôle* that minerals played in the great struggle between autocracy and democracy and the part they now will have in the reconstruction of the world furnish the subjects for discussion here presented by a group of geologists in the Government service. In their effort to make the Nation's minerals count their utmost in the war crisis, these specialists have learned to see with broader vision the use that may be made of these natural resources. It is now necessary to plan the larger reorganization of industry for the years of peace that are to follow. In this strategy of a nation full use of our mineral resources is demanded, as well as the best use of our man power.

The inevitableness of industrial and commercial reconstruction, world-wide in scope, was declared publicly by the Secretary of the Interior five years ago at the outbreak of the Great War, and now at its close it is appropriate that in another "foreword" Secretary Lane should set forth the national purpose that must inspire America's use of her resources of men and material.

George Otis Smith.

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INTRODUCTION

The more I see of modern industrial tendencies, and the closer I have come to an insight into modern international troubles, the more convinced I am that there will be no end to wars and threats of war, to many so-called racial and national conflicts, until the nations of the world regard themselves more really as the trustees of their resources, not merely for those of the same nationality, but for the world at large.

A modern nation must have iron. This metal is the very basis of industrial life. A people like those of the Hawaiian Islands, who have a generous soil and a climate that fairly seduces this soil into its highest productive power, may be self-supporting by the slightest importation of iron and steel products. Even with the wooden plows of Pharoah's time such lands could probably be made to yield enough of fruits, vegetables, and meats to support as many people as now live on these Islands of the Blest. But this is not a picture of the world. With the steam engine and the multitudinous machines that have followed it as dependents, the old agricultural world has been turned topsy-turvy. Whole peoples, like those of England, have come to be makers of things, industrialists, not raisers of things. And all nations are bent in the same direction. This is the meaning of our trend toward the city, of our tenement-house problem — we are gathering our people into masses to work upon raw material with machines made of iron.

And, of course, there is another factor not to be overlooked. This is an age of organization, of superintendence and direction. The man who can train and lead others, the captain, has found his place in this world where large numbers can produce in greater quantities

for less cost. Industrialism consists, too, not less in making men want something that they did not want before than it does in meeting that want. We have an endless repetition of circles. One man pipes water to his house, and soon all men must have water piped to their houses; pipes for water make a demand that opens new mines and mills, and new mines and mills make a demand for new houses and new pipes; and so the process continues. Each new thing done runs back and back, calling for more from the earth, and more hands to handle it, and more men to manage men. Our display windows, our catalogues, and our commercial travellers are lures — they are not exclusively to supply what is actually wanted, but to arouse desires that have not before been consciously felt. And from creating these desires there follows the construction of great plants to meet them, and organizing brains, and demand for more and more men.

This is the new world into which, practically within a century, we have come. It is a very democratic world in the sense that it allows the bulk of the people to make the demand. There must be a general demand, not a limited demand. Industrialism is planned to meet the call of the people, not the whim or conception of a king or a limited group. It is a world of artisans, not a world of artists. It aims not at the one noble palace or temple or statue or bit of tapestry, but at many minor things of beauty and utility.

And the basis of all this change has been the production of the tool made of steel.

The peoples that have ambition for prominence, that wish riches and advancement even at the price of contentment, will find some way in which to secure those metals which are the masters of the new day of industrial progress. They will fight if necessary. This seems inevitable. And the part of statesmanship is to find a

way out. If the United States contained all the iron and copper and a half-dozen other minerals of the world, it could be the "world controller." All other nations would be dependencies. We would be in as strong a strategic position industrially as we would if we owned all the wheat-producing lands of the world and all the rice lands. The hand of every man would be held out in suppliance to us, but inevitably the other hand would in time be raised against us. We could not lock up our mines and tell the world to whistle. We could not treat ourselves as the owners in fee of this foundational wealth. We would be driven to open it, use it, distribute it, or it would be taken from us.

So it must be. The right to have implies a duty to use. There is an international right to those things which are essential to life, a greater international right than that which the ships of all nations must have to pass through the Panama or the Suez Canal. We are to grow nationally by our generosity internationally.

The American people should be the most independent people on earth. There is little of mineral wealth that we do not find on our continent. It is to our benefit that all of the minerals should be found and brought out. For upon our shoulders rests the burden of proving that free government can live. America is the ultimate citadel of liberty. This is not Fourth of July boasting. It is an all too solemn fact, as the last four years have proved. Therefore it comes upon us as an unparalleled and unforeseen duty to make of this land all that we can, to see that there is food enough produced here for all our people. And to this end we must see that our soil is not exhausted; that we develop our phosphate deposits, our potash resources, and our nitrogen possibilities; that by preserving our forests we protect our soil from being washed away; that we find substitutes for the most wasteful drains upon soil. It is likewise and no less incumbent upon us that we make search in

every mountain and valley from the Seward Peninsula to Porto Rico, and from the Philippines to the Bay of Fundy, for all those mineral resources for which we are drawing on the outside world, such as tin, antimony, pyrites, chromite, platinum, and others of that small group of minor minerals which in our respect for great things we have overlooked either as negligible or as being produced elsewhere in sufficient quantity for our need.

The war taught us the need for mineral independence, and now that peace has come we should not forget it and be lured into the sweet illusion that all is forever to be well. And yet all this should not be done with the thought either of making of ourselves a safe fortress or of merely adding to our individual or national wealth. We are the world's trustees. And recognizing this principle, we should use our influence to make others accept this same doctrine as the surest foundation for international peace in a world so wrought up over the value of industrial competition. The worlds of finance and of statesmanship, those who wish for international peace and good will, should think seriously on this suggestion. We in America have found that we cannot live unto ourselves alone; neither can any other nation. We are given a portion of the world as a challenge to prove our right and capacity to hold it and bring out of it all that it has that the men of all nations need. And this must be the challenge which all peoples meet.

FRANKLIN K. LANE.

THE STRATEGY OF MINERALS

CHAPTER I

INTERNATIONAL RELATIONS AND ECONOMIC MINERALS

LESTER H. WOOLSEY[1]

Relation of geographic position and economic resources to international influence — Racial characteristics — Evolution of states from racial groups — Qualities of statehood — Two elements of a state: its individual membership and its territory and geographic position — Intercourse between states — Effects on foreign relations of characteristics of peoples — Color and form — Language — Religion — Intelligence — Initiative — Effects on foreign relations of geographic position and characteristics — Accessibility — Freedom of communication and trade — Topography — Climate — Food resources, plant and animal — Mineral resources — Disadvantage of national dependence for mineral supplies — Mineral raw materials in international relations.

An eminent geologist-engineer recently made this statement in a letter to me:

> I do not need to point out to you, as I tried to point out long ago to my friends in —— that it was the minette iron deposits which enabled Germany to continue the war. A complete plan for the aerial bombing of the head-frames and pumping plants of the German iron mines was proposed and laid before the Allied military chiefs, . . . but it was one year after it was proposed before they took action on it.
>
> As a matter of fact, one should look to France becoming a very powerful nation now that she has obtained the possession of these great mines and mining districts which were taken from her by Germany in 1871.

I cite this statement not only because it illustrates vividly the "strategy of minerals," and because it indicates the importance of the geographic position of nations

[1] Solicitor of the Department of State.

with reference to the resources of the earth, but because it suggests that there may be a relation between the peoples of the globe and the geographic position of the country which they inhabit, on the one hand, and, on the other, their activities and influence in the realm of international affairs. To examine more fully this suggested relation is the purpose of this chapter.

If we look at the world as the habitation of man, we are impressed by the fact that it is populated almost everywhere that human beings are able to exist. It probably had been so populated for thousands of years before the recorded history of man. In prehistoric time, as now, the inhabitants of the earth consisted of races of men having marked distinctions in color, physique, religion, and other characteristics. The migrations of these races during the historical epoch it is not necessary for our purpose to trace, even if it could be done with accuracy. The important facts are that these races exist today, and have maintained as a rule, and in many instances with singular purity, their racial characteristics, notwithstanding their intercourse with one another.

The community of interest, whether material, generic, or sentimental, which bound members of the same race together and dissociated them from members of the other races, gave rise in early times to the interracial relations comparable with international relations of today. One race regarded another with amity, jealousy, suspicion, fear, or hostility according to its relations with that other were friendly, strained, or broken. Individual members of a race held a peculiar status when they visited another race, and they were seldom, if ever, accorded the same rights and privileges as lineal members of the race they visited.

These races slowly evolved some form of organization

or government: merely patriachal at first, when pastoral conditions required mobility; stationary when a permanent agriculture became possible; complex with the division of labor and growth of industry. So the Egyptians, Israelites, Greeks, Romans, Goths, and others came into history as nations — as races with governments. This natural division of men into homogeneous races, each with its own government, was broken down by wars of conquest or annihilation, as a result of which the governments of the conquerors were imposed upon the subdued races. Consequently today, although the inhabitants of the earth are still divided into races, there has been imposed upon the weaker the yoke of the stronger, and the spectacle of equal, coördinate, and independent races is replaced by that of equal, coördinate, and independent governments, some of them governing several distinct races. By this regrouping of diverse races under a single government, racial distinctions have tended to obliteration, racial barriers have been partly broken down, and the intercourse between the racial divisions of the primeval world have been replaced by intercourse between the governmental divisions of the modern world.

These governmental divisions came to be called "states," which term has a technical legal meaning in international relations. A state is generally defined as a body of individuals with an organized government controlling a definite territory and enjoying freedom of action, independent of any other country in affairs of both domestic and foreign concern. Such an equity is distinguished in international parlance from a "nation," which term is commonly used to designate peoples of the same generic characteristics of color, language, and physique (such as the Jewish nation or the Slavic nation), regardless of governmental organization, terri-

torial possession, or political independence. The term "state," on the contrary, is generally applied to artificial political entities, which may be composed of several different races of people living under the same government and within the same geographic boundaries. For example, Austria-Hungary, with its several races, was formerly as much a state as Greece, whose inhabitants were largely Greek.

Although states may differ widely in size, power, and influence, these conditions do not change their international status. San Marino, having an area of 32 square miles, the smallest independent state in the world, is just as truly a state as Great Britain or the United States. Nor does the fact that the territorial possessions of a state are not contiguous affect its international status. All territorial possessions under the same general government are counted, in an international sense, as one with the mother country. Thus Great Britain with its colonial possessions and overseas dominions, though widely scattered over the earth, is regarded internationally as a single state.

The form of government maintained in a state may affect the happiness and welfare of its people, and so may indirectly affect its rank among nations, but so long as a state accords foreigners just treatment, its form of government has ordinarily no international significance. Its government may be despotic or free, monarchial or republican, but these differences do not affect the character of a state as an international entity.

Independence from interference by other states in domestic concerns and international rights is, as we have seen a quality of statehood. This quality, however, may among some of the weaker countries of the world be somewhat limited, in order to prevent encroachments

upon territorial or political integrity by more powerful states. These limitations are generally embodied in treaties with the weaker state, and may restrict the right to make war, as in the "neutralization" of Belgium, Luxembourg, and Switzerland; restrict the right to enter into treaties without the consent of the greater power, a limitation imposed upon Morocco in respect to France and upon Cuba, Haiti, and Panama in respect to the United States; impose the obligation of taking identic or joint action, as in certain alliances; and restrict the exercise of certain domestic rights, such as the increase of the public debt of Cuba, Haiti, and the Dominican Republic without the sanction of the United States, the collection of revenue in the Dominican Republic and Haiti, the exercise of extra-territorial jurisdiction in China and formerly in Morocco, Turkey, and certain other countries, and the exercise of jurisdiction over specified areas within a foreign state, as the leased areas of China. All of these limitations on the independence of a state have their effects on its international relations, and ordinarily result in closer commercial and possibly closer fiscal relations between the states concerned, as well as in greater deference on the part of the minor state to the wishes of the guardian state in general.

It will be observed from this discussion that the state consists primarily of a group of persons organized into a society for self-government, and secondarily of a limited territory over which the organization asserts control. In this discussion special attention is called to these two elements of a state — the individuals who compose it and the territory which it occupies.

Individuals compose the membership of a state as well as the agencies through which its government acts. A government has intercourse with other governments

through individuals. Intercourse between governments, commonly called official intercourse, is, however, only one of the many activities of individuals composing a state. There is intercourse by individuals in their private capacities in behalf of their own personal interests, through individual effort or organized commercial bodies, such a corporations, societies, or associations. The bulk of this non-official intercourse consists in the exchange of raw materials, manufactured products, and works of art and literature. There is also social or other intercourse, such as travel, sojourn, or residence of persons in foreign countries in the pursuit of study or pleasure. Whether intercourse of individuals is carried on through official channels in behalf of their governments or by private means in their own personal interests, it is important to observe that the individuals are the active agents of such intercourse.

The territory under a single governmental control may be a large one, such as that under the dominion of the British Empire, or it may be a subdivision of such a territory administered by a local government, such as that under the Government of Canada, of Australia, or of the Panama Canal Zone. Whether the whole territory of a state or merely that of a subdivision is to be considered in connection with the activities of nations and their international relations depends upon the objects in view. For the purpose of considering the power, wealth, and influence of nations, it is common to consider all the territories under one central jurisdiction as a unit, but in considering special features of national or international activities, such as routes of trade, or the value of particular resources (as the wheat lands of Australia or the nickel deposits of Canada), parts of the jurisdictional unit may be considered separately. Whether the

whole or a part of the territory of a state is taken into consideration, it is important to realize that the size of the territory is a question of minor significance, except in so far as size may allow the use and enjoyment of the advantages flowing from geographic position.

The geographic position of the territory of a state carries with it not only advantages but also disadvantages. A few nations are entirely landlocked; others are almost surrounded by adjacent states; others have no winter seaports; others are wholly or largely surrounded by seas; others are rich in river communication; others are mountainous or rolling; others are located in the torrid or temperate zone; and still others are subject to high precipitation, or little, or none at all. The British Empire, with its extensive area (approximately 13,153,000 square miles), distributed over the globe, commands a variety of climate and resources which, coupled with the enterprise of its people, have made it one of the greatest powers of the world. The former Russian Empire, on the other hand, with an area two-thirds as great as the British Empire (approximately 8,417,000 square miles), was so largely located in a severe climate and so poor in natural facilities of communication that its backward people have never been able to win the first rank among nations.

It is obvious, therefore, that the two fundamental elements of international relations are, *first,* the individuals composing the body of persons within the territories of a jurisdictional unit, and *second,* the geographic position of the territory within those boundaries. The individuals and the geographic position of the territory they occupy form the groundwork of international intercourse. Indeed, the success of a state internally and its rank among other states may be ultimately traced to

these elemental considerations. In any study of international relations, therefore, we should examine the characteristics of the individuals making up the states and the physical conditions of their environment due to the geographic position of the territories they inhabit.

The characteristics of the inhabitants of a state are, on the whole, the characteristics of race, such as color, form, language, religion (ethics), intelligence, and initiative energy. Color or form, which go to make up physical appearance, undoubtedly have some influence on the intercourse between races in which these characteristics are widely different. The relations of the white, yellow, and black races, for example, are not intimate, and this lack of intimacy is probably due, at least in part, to differences in physical appearance. It can hardly be expected, therefore, that states composed of these races, strikingly different in color and form, such as France, Japan, and Liberia, would have as close official and trade relations as states composed of the same or similar races. The mere personal antipathy which, whether rightly or wrongly, the white man entertains for the black man has kept these two races apart. To this antipathy is due, for example, the isolation of Liberia from other nations, for relations with Liberia have been confined to intercourse for purposes of trade rather than for social benefit.

Language is an obvious characteristic of peoples. What is its effect on their development and intercourse? It may be said that the most progressive nations of the world speak the English, Romance, Germanic, or Japanese languages. No tongues more diverse could be selected, yet it cannot be said that, other things being equal, one language or another has been a deterent to civilization or to international intercourse. Probably

ideas could be borrowed and assimilated more easily and rapidly if there were but one language, but translation has become so easy and printing so common that difference in language interposes no material obstacle to international intercourse. Similarity of language, however, is not without its effect, for language is the expression of thought, and similarity of expression indicates similarity of mental processes, so that there is a natural understanding and a common sentiment between peoples using the same or very similar languages. The United States and Great Britain, Spain and the Latin republics of South America, Portugal and Brazil, China and Japan, Germany and Austria, are examples. As between countries of each group intercourse is no doubt facilitated by the use of a similar vehicle of thought. On the other hand, at certain language frontiers, such as those of the Polish provinces and those of the Balkans, the intermixture of language is so nearly homogeneous as largely to remove any barriers of language to freedom of intercourse. Again, the intercourse of a country in which diverse languages are spoken, such as Switzerland and the United States, with other countries speaking those languages is probably facilitated by this diversity of tongue. On the whole, however, the actual effect of language on international relations is of secondary importance.

As to the effect of religion (ethics) upon international relations, it may be said that religious faith has had a mighty influence upon the political history of the world. The kind of religion that prevails in any age or state is not so important as the sway it exerts. It creates a community of interest, a unity of purpose, and on occasions becomes an irresistible force — a force which may accomplish astounding things. Witness the conquests

made by the Arab tribes under the influence of Mohammedanism and the establishment of their immense empire. The aggressive Mahomet, the pacific Buddha, the self-sacrificing Christ, had their peculiar influences on the peoples who fell under the sway of their teachings. The religious spirit has played a political *rôle* of importance among the nations. Mohammedanism transformed southeastern Europe; the Crusades were an effort to shake off its influence; Buddhism and Confucianism spread contentment and seclusion over the Orient; Jean d'Arc saved France through a religious fervor that inspired a whole people; Spain had its Inquisition, and England its Puritanism. All these chapters of religious history show what peoples may do under the influence of fanaticism. They illustrate, of course, the white flames of religious heat of past days rather than the quiet glow of the religious faith of today. Nevertheless, the influences of Buddhism, Mohammedanism, Confucianism, and Christianity are subtle and widespread at the present time.

Other things being equal, a people entertaining one religion look with suspicion, pity, or contempt upon a people professing an entirely different religion. This prejudice may be said to be gradually passing away, but it nevertheless exists, and it is adverse to the intimate intermingling of nations. One of the practical effects of religion or ethics on international intercourse is shown in the influence of honesty and fair dealing in commerce. Where traders hold mutual confidence in one another's honesty, there is freedom of commerce. A religion of high ethical aims, like Christianity, no doubt embues higher respect for and confidence in peoples who profess it than a religion that is lax in this respect, such as Mohammedanism. Compare, therefore, the

mutual confidence and the freedom of commerce between countries of Europe with the lack of it between those countries and Turkey. By this confidence even the larger transactions of commerce are affected, such as loans to foreign governments. Great Britain, for example, can more easily negotiate a loan than Turkey because there is greater confidence in the securities.

Religious belief, however, does not to-day necessarily determine the rank of nations. Christianity prevails, it is true, among most of the nations that stand high in the scale of civilization, but it prevails also in countries low in the scale. Similarly, Buddhism ranges from the high civilization of Japan to the low civilization of Tibet. Even Mohammedanism ranges over peoples of a medium and low civilization, although it is not the religion of any of the most advanced nations. In short, differences in religious belief and ethical standards do not make for intimacy in the relations of nations, but they are minor factors of influence in such relations.

The intelligence of peoples is an important factor in international intercourse because there are great differences in the intellectual ability of different races. For example, the relative efficiency of white and negro farmers in the United States is in the ratio of two to one in the northern states and about five to three in the South. On the whole, illiteracy among the black, brown, and red races is estimated to be roughly three times as great as among the white races. Exact data for comparing the intelligence of other races is not available, but there are unmistakable indications that there are racial differences in mentality as well as in outward appearance. Intelligence is shown in the ability of men to organize and administer their affairs. A government is the product of such mental power — not the form of

government, which may be a shell without substance, but the efficient exercise of the functions of government. The republican form of government is common now throughout the world — in North and South America, in Switzerland, France, and even in China, in Turkey, and elsewhere, but it will no doubt be conceded that the most efficient examples of republican government are in the United States, Switzerland, and France.

Linked with the factor of intelligence is that of initiative. Initiative depends perhaps less upon intelligence than upon energy, and one without the other is of little effect in the relations of states to one another. Initiative, that is, originality, inventiveness, enterprise, is a distinctive quality of certain races. The highest initiative ability appears to be possessed by the peoples inhabiting central Europe and North America. These peoples have the capacity of formulating new ideas and carrying them into effect, and this capacity is coupled with highly developed self-control. Peoples ranking second in this respect are the Japanese and the Latin races in certain localities.

It is generally recognized that there are racial differences in the workings of the mind and in the energy for carrying out ideas that are ineradicable. The primitive Igorrotes of the Philippine Islands probably would not develop a high civilization wherever they might live. They might be stimulated by external conditions to improve their capacity, but there is not a chance in many thousands that they would reach a plane comparable with that of the Anglo-Saxon. Great Britain and Turkey may be equal before the Hague Tribunal, but commercially in time of peace or as belligerents in time of war the two nations are hardly comparable. The development of the two peoples, of their governmental

systems, and of their national resources has been strikingly different, and to compare them is merely to illustrate the great difference in the degrees of civilization that have been attained by different peoples of the world. Although intelligence and initiative no doubt differ remarkably in different races, factors other than that of race materially affect these qualities. The most potential factor perhaps is location on the earth's surface.

It seems evident, then, that differences in the color, form, and language of the inhabitants of states are of minor importance in the foreign relations of those states, whereas differences in intelligence and initiative are of far-reaching effect and primary importance, although these are probably themselves affected by other factors, particularly by geographic position. All of these characteristics of race have had their effect on international intercourse, but intercourse itself has no doubt had in turn its effect on race, particularly in its progress and civilization. For the contact of two cultures, according to the laws of heredity, tends to make a superior culture by the selection and survival of the best elements of both. Perhaps the superiority of the English-speaking people today is due in large part to the amalgamation of the races from which it has been formed.

Turning now to the consideration of the second fundamental element in international relations, geographic position, let us notice briefly the incidents of geographic position, namely, accessibility, topography, climate, resources, and other physical characteristics of territory, and their effects on the affairs of nations.

The inaccessable or isolated situation of certain countries and the exposed position of others have had considerable influence on their progress in civilization, and consequently on their international relations. Some na-

tions have acquired sea power and maritime supremacy, others have lost control of the seas or have never aspired to sea power. Great Britain has gained control of the seas and of sea-borne commerce against Spain, Holland, and other countries, and has in the Great War been fighting for supremacy on the ocean against her enemies. On the other hand, Switzerland, Serbia, Bolivia, and Paraquay, having no front on the sea, support no navy or merchant marine, and consequently have attained no great position in international trade. The insularity of England and Japan has not only contributed to the growth of their naval power, but has no doubt had an influence on the character and the culture of their inhabitants. These countries have gained protection from invasion by virtue of their insular character; Switzerland is secure in its mountain fastnesses; and the United States finds safety in its isolation. Compare these countries with China, which has been overrun again and again by Tartars, Manchus, or other peoples; with Korea, invaded by Chinese hordes; with Turkey, swept over and harassed on the borders by alien races. Isolated countries have not encountered such hindrances from without; they have had an opportunity to develop their own ideas and character. The desolation wrought by the hosts of Germany and Austria-Hungary in the contiguous countries of Europe shows in striking manner how prosperity can be stricken down by the hand of the invader. Clearly the protected countries have the greatest opportunity to expand their international relations and to establish themselves in the market of the world.

Geographic location obviously determines in large degree the facilities of a country for communication with other parts of the world. In Egypt, the first home of civilization, the Nile was the chief route of navigation,

and the early sailors hugged from point to point the shores of the Mediterranean. After the compass was invented and perfected by seafaring peoples, the great water routes of the world were opened to navigation. The Phoenicians by the art of sailing extended the sphere of navigation to Italy, and thereupon trade grew up between the eastern Mediterranean and India. In this trade caravans crossed the intervening deserts along routes which were afterward followed for thousands of years. This was the first great route of trade between Asia and Europe, and remained so until the dangers of navigating the ocean were overcome by the construction of better compasses and stronger boats. Navigation in the Mediterranean and on the western coast of Europe became more and more extensive, and at the same time trade routes were established up the Danube and northward from Venice to the Hansa towns on the north coast of Europe. Thus two commercial centers grew up, one in the Mediterranean in Italy and farther east, and the other along the shores of the north coast.

About this time the Turks in their western movement began to occupy Asia Minor, Phoenicia, and Egypt, and to intercept the overland trade routes with the East, as well as the Danube route to the north. Almost contemporaneously the art of navigation progressed to the point where men were prepared to venture in distant waters, and the period of discovery began. New trade routes were found around the south of Africa to the East and westward over the ocean to America, and new trade centers were established at first in Portugal and later in Spain. These were the dominant trade centers for nearly a century until the leadership in foreign trade passed from Spain to Holland, from Holland to France, and finally from France to England.

It should be noticed that this westward advance of trade and civilization was greatly facilitated by the great waterways — the rivers and the seas — of the world. The navigation of the Nile and the Ganges, the Red Sea and the eastern Mediterranean, the coastal waters of the eastern Atlantic, the Atlantic and the Indian Oceans, has been the slow development of centuries. The location of trade centers and the intercourse between them has been controlled to a large extent in the past by ready means of water transportation and communication, and the countries that attained the greatest wealth, power, and influence were those most conveniently located by the sea.

The topographic features of a country affect not only its isolation or its accessibility, but also, it would seem, the character, or at least the development, of the inhabitants. In China, for example, no amount of individual forethought or energy can prevent the destruction of crops, homes, and wealth by the floods which sweep down from the Himalaya Mountains and which help to make the struggle for food even in the flood-free districts in the hilly country sharp and continuous. And in Japan the topographic features render only about 14 per cent. of the land fit for cultivation. The result has been the survival of the fittest and a tendency toward the development of a hardy, strenuous race. The influence of topography on the activities of a people, however, cannot be entirely separated from that of climate.

That one people is more intelligent, more industrious, and more enterprising than another people is clear. But whether these differences are due to the natural mental and physical superiority of certain peoples or due to the reaction of physical surroundings upon them has long been a debated question. Climate appears to cause

variations in the forms of plants. The heads of clover which are round and fully developed at moderate altitudes are reduced to two or three flowerets on the top of Uncompahgre Mountain in Colorado, a peak about 14,000 feet high. Sumner and others have also noticed differences in animal forms that are apparently due to the effect of climate, such as a decrease in the length of tails of mice reared in cold rooms, and an increase in stature of English colonists in Australia. These are physical changes, but may climate not have also an effect on the mind? The change of seasons in the Temperate Zones requires constant forethought and industry on the part of the inhabitants of those zones, and probably has had its effect on their advancement. One of the latest contributions to the study of the effect of climate on man is presented by Ellsworth Huntington, a geographer who bases his conclusions on data collected in many parts of the world. He points out that there are, to speak in barometric terms, areas of "high-pressure" civilization interspersed over the globe with areas of "low-pressure" civilization. He states that there are five "high" areas, one corresponding roughly to the United States north of Mason and Dixon's line, another to the British Isles and Central Europe, a part of Italy and the Baltic coasts, a third to Japan, a fourth to New Zealand and southeastern Australia, and a fifth to the southern extremity of South America. These areas have peculiar climatic conditions, marked by frequent cyclonic storms and rapid successions of moderately high and low temperatures ranging from about 30 degrees to 70 degrees F. and the view is advanced that such changes may perhaps stimulate mental and physical activity and thus have great effect upon the position of a people in the scale of civilization. If this is true, it

leads to the conclusion that possibly no countries that have a warm, equitable climate and but slight successive changes in temperature can attain the same degree of civilization that is attained by countries situated in harsher climates. Thus, other things being equal, we may conclude (though perhaps from insufficient data) that certain nations — for example, those in or near the Torrid Zone — will always rank among the least advanced, and therefore will be subject to the dominating influence of their stronger neighbors.

This conclusion is strengthened by a consideration of the enervating effect of warm climates upon the human race. This deteriorating effect is evident in the moral laxness of the inhabitants of the tropics, even of those who may have come from a more rigorous climate. Self-control is lacking; heavy drinking, violence, and other excesses are prevalent. Moral degeneration is aided and hastened by the lack of necessity for exertion or forethought in obtaining food and clothing adequate for the season's needs. Indeed, the common opinion of observers appears to be that hot climates tend to reduce all races to the same sublevel of inertia, laxness, and ignorance.

Climate has its effects not only seemingly upon man, but it has perhaps a more striking effect on plants and animals. The distribution of the essential plants used for food and clothing is determined largely by temperature and precipitation. Agricultural resources are grouped, roughly speaking, in latitudinal zones extending around the earth, though the form of these zones are more or less modified by the influence of ocean currents and altitude. There is a cold northern and a cold southern zone, in which rye or other hardy plants grow; another zone less rigorous, where wheat, oats, corn, and barley thrive; and a warmer zone in which rice, cotton,

citrus fruits, and sugar cane flourish. Obviously, an exchange of commodities by nations occupying different agricultural zones is necessary, and this exchange constitutes international trade and commercial intercourse. Countries that have abundance of certain products export the surplus to nations that have an insufficient supply. Thus, in normal times the great wheat-producing countries, such as Russia, United States, Canada, Argentina, India, Australia, and Rumania, export their surplus wheat to France, Italy, Germany, the United Kingdom, Spain, Japan, and other countries; Russia, Rumania, and the United States export quantities of corn to other countries of the world; the countries of eastern Europe produce the bulk of the oats exported to the United Kingdom and other countries; Russia, Austria-Hungary, India, Rumania, and the United States produce the bulk of the barley exported to Germany, Great Britain, The Netherlands, Belgium, and France; India, French Indo-China, and Siam produce a surplus of rice for export to Dutch East India, Germany, Singapore, Ceylon, The Netherlands, the United Kingdom, Japan, and China proper; the United States, India, and Egypt produce practically all of the world's cotton and export large quantities of it to other countries; the United States, Dutch East Indies, Brazil, Cuba, India, and Russia grow considerable tobacco for export. Over 90 per cent. of the world's crop of potatoes is raised in Europe, three-fourths in Germany, Russia, and Austria-Hungary; three-fourths of the world's exports of sugar come from Cuba, Java, Germany, and Austria-Hungary, and three-fourths of the world's imports go to the United States, the United Kingdom, India, China, and Canada; the Mediterranean region, particularly Spain, Italy, and Sicily, produces citrus fruits for most of Europe; Brazil

produces 70 per cent. of the world's crop of coffee; and Asia produces most of the tea for the rest of the world.

It is evident, therefore, that the great purveyors of the world are in normal times Russia, the United States, Canada, India, Egypt, Australia, Argentina, Rumania, Austria-Hungary, Germany, French Indo-China, and Siam, and that the special adaptability of certain countries to the production of agricultural products is one of the great bases of international trade and intercourse. Indeed, so great is the dependence of many countries upon the agricultural products of other countries that to cut off supplies of two or three articles might bring distress or ruin, not only to the producing country but to the consuming country as well. This fact was effectively used by the Allies during the Great War to prevent materials from going into Germany from contiguous neutral countries. By "rationing" the neutral countries or by withholding from them certain commodities essential to their wellbeing, the Allies were able to influence the neutral countries to limit the amount of agricultural products and other materials to be exported to Germany. Probably in no other way could the so-called "blockade" of the Central Empires have been maintained during the period of submarine warfare. Few countries, if any, are independent of the remainder of the world for their food supplies. The United States is in this independent position in respect to the principal food corps (corn, oats, wheat, barley, potatoes, rye, and rice), but must import coffee, tea, sugar, cocoa, bananas, and olive oil, all of which, except tea and olive oil, are supplied by countries in the western hemisphere. It is this enviable self-sufficiency in the supply of food and preëminence in its production *per capita* that has contributed prosperity and stability to the New World and diverted the current

of migration westward from the Old World where economic conditions are far less favorable.

On the other hand, the marked lack of self-sufficiency in plant products on the part of certain countries, particularly semi-arid countries, is highly significant in international politics. For example, the lack or irregularity of rainfall in Turkey makes permanent agriculture a precarious business and causes the nomadic habits of the people from which follow a train of evils, such as perpetual unrest, intertribal fighting, ignorance, poverty, fatalism, and poor government.

In this relation it is interesting to note the effect of the development and distribution of certain food plants. Corn, probably first brought under cultivation in Central and South America, has now spread to Europe and Asia, and forms one of the most important cereals of the world. Rice, which was cultivated originally in the Orient, has been added to the food supply of Europe and the New World. Potatoes, which were of American origin, have been adopted in Europe, where over 90 per cent. of the world's production is now grown. In northern Europe the cultivation of potatoes has revolutionized agriculture, has made possible the sustenance of a great increase in population, and no doubt has promoted social and political contentment. The introduction of the sugar beet into the Temperate Zone has greatly modified the trade in sugar-cane products. Coffee, which is indigenous to Abyssinia, has been carried to Arabia, India, Ceylon, Java, Hawaii, Brazil, West Indies, and Central America, and Brazil now produces 70 per cent. of the world's crop. These instances show the effect of food plants upon the international life of the world. Similarly the effect of drug plants upon international relations is significant. For example,

quinine from Java was a necessity in Italy during the recent war because the prevalence of malaria there threatened, so it is reported, the efficiency of the army.

Climate affects not only the character and distribution of plants, but to a similar, though probably smaller extent, the character and distribution of animals, at least in so far as they affect the domestic economy of peoples and their mutual dependency. For example, beasts of burden are of different kinds in different parts of the world, the kind used in any particular region depending largely on the condition of the feed supply and the character of the climate. Since horses cannot be raised to advantage in arid or semi-arid regions where forage is scanty or in certain tropical countries where they are liable to disease, they are found mainly in the Temperate Zones where the agricultural conditions are best. Consequently their distribution corresponds roughly with the location of the most advanced and wealthy countries of the globe.

On the other hand, mules and asses, on account of their ability to subsist on sparse vegetation in dry climates, are most abundant in the hot and dry regions. They are not only able to subsist on harsh and meagre forage, but they are notably sure of foot, and for these reasons they are the common beasts of draft and burden in Brazil, the Andean countries, Mexico, South Africa, Turkey, and in parts of the United States. The distribution of mules and asses is, roughly speaking, indicative of rough, dry lands of inferior agricultural value and of poor peoples.

Moreover, the number of horses, mules, or asses per square mile and *per capita* in different countries is a rough index of the advancement and efficiency of the peoples inhabiting those regions. For example, in

Asiatic Turkey, the Orient, northern Africa, and certain parts of Mexico and Central and South America, the very small number of horses in proportion to the population indicates that human labor is plentiful and cheap and supplants that of beasts of burden. Manifestly, a people that performs all or almost all of its own labor cannot become so efficient as a people that employs animals for this purpose. This is perhaps one reason why the North American Indian, having no beast of burden available, never advanced far in the practice of agriculture or rose high in the scale of civilization.

Turning to animals that yield food and clothing, it is found that their production is limited largely to the North Temperate Zone. This is mainly due to the fact that little meat is consumed in the tropics and that the population of the South Temperate Zone is as yet comparatively sparse. This does not mean, however, that animals suitable for food will not thrive in other regions, particularly in those warm regions where forage is plentiful and economical. On the contrary, the character and amount of forage available has a direct effect upon the geographic distribution of grazing animals supplying food and clothing. Northern and central Europe, eastern United States, southern South America, and India are adapted to the support of cattle; whereas the dry, rough, untamed lands, with sparse population, of Asia Minor, the Balkan States, and certain parts of South Africa, Australia, and New Zealand are suitable for the production of sheep and goats.

As grazing animals that yield food and material for clothing are distributed according to the parts of the world where they thrive best with human care, an exchange of animal products between different countries is necessary, and this traffic becomes an important factor

in international trade and relations. Omniverous animals, however, such as swine, the distribution of which depends more upon economic conditions than upon climatic conditions affecting the supply of forage, may be widely distributed over the countries of the earth and enter but slightly into the international exchange of animal products.

We come now to a consideration of the mineral resources of the countries of the world with a view to ascertaining their effect upon international affairs. Although climate has modified the distribution of the plants and animals of the world, the transitions from kind to kind are gradual and the distribution is broad and possible of extension by human effort. This is not true of the mineral resources of the world, for they occur, as a rule, in layers, beds, or veins of comparatively very limited extent. The area of the mineral deposits in any region is restricted and fixed, or static, so to say, and cannot be increased or decreased by the efforts of the inhabitants of a territory, although the deposits may be made available by development. Therefore the presence of minerals within the boundaries of a state is a fundamental, unalterable advantage to that country, and their absence a fundamental, unalterable drawback. A country that has little or no mineral resources is in a position of insuperable disadvantage as compared with a country that has a sufficiency of the essential minerals. There is no certain way to overcome this disadvantage, although it may be to some extent alleviated by trade at the sufference of the dominant states. But if such "commercial penetration" becomes obnoxious, the territorial sovereign may curtail facilities to foreigners, as England and France are now said to be endeavoring to do in respect to certain industries.

The presence of mineral deposits in a region does not render them valuable unless the inhabitants know how to use them. The North American Indian, for example, lived for centuries in the most self-sufficient country in the world in respect to mineral deposits, but he knew practically nothing of their use. A similar statement might be made of certain other backward races. The Assyrians were probably the first to convert iron into tools and weapons, thus to steal a march on the Indian and other peoples in the race of civilization. The discovery of the uses of iron was handed down through centuries and an enlightened people came to North America, superseded the Indian and took possession of his country, which is the richest in the world in mineral deposits. Now that the uses of practically all minerals are known and the location and extent of most of the world's mineral deposits are common knowledge, the rise and fall of nations depend essentially on the extent and relations of the deposits and on the intelligence and enterprise exercised in their development. But intelligence and enterprise cannot produce great national wealth unless they can be applied to the exploitation of extensive and economically related deposits. The countries of the globe having adequate supplies or exportable surpluses of the 31 principal minerals [2] of commercial importance may perhaps be ranked roughly as follows: United States, British Empire, France and colonies, former Russian Empire, Germany, former Austro-Hungarian Empire, Spain and Portugal, Mexico, China, Japan, Italy, Sweden, Chile, Peru, Belgium and colonies, Bolivia, Norway, Colombia, Brazil, Serbia, Rumania, etc.

[2] Coal, oil, gas, iron, manganese, chromite, nickel, tungsten, vanadium, molybdenum, copper, lead, zinc, platinum, silver, gold, phosphate, nitrates, potash, pyrite, sulphur, mercury, tin, antimony, arsenic, bauxite, aluminium, graphite, magnesite, sheet mica, salt.

From this discussion several conclusions may be drawn. In the first place, countries that have a monopoly or a preponderance of certain essential minerals must supply those countries that are deficient, and thus international trade is promoted. In the second place, the countries that have an abundance of the necessary minerals are bound to be the wealthiest, most powerful, and most influential nations of the globe, provided the inhabitants rank high in the scale of intelligence and initiative. The valuable resources of the United States have in a large measure caused her rapid rise to power, wealth, and influence among the nations of the world. She has, moreover, the elements for maintaining her place in the civilization of the world, for obtaining prosperity in time of peace, and for providing the sinews of war. And her people have been able to conceive or adopt the great inventions of the age, such as the steam engine, the gas engine, the steel vessel, the telephone, the telegraph, the airplane, and to produce them from materials at hand. In the third place, a country that has a monopoly or dominant supply of one or a few minerals will use them as leverage to obtain from other countries the supplies that she lacks. For example, Germany before the war possessed the only large deposits of mineral potash in the world, and, therefore, believed herself able to exact supplies of other raw materials that she lacked, such as copper, rubber, and cotton. This situation leads to alliances, controversies, or wars. The contest between France and Germany for the coal and iron deposits of the border provinces is a case in point. Germany's access to the rich ores of Sweden and to the chrome ores of Asia Minor through her alliance with Turkey and her capture of the Rumanian oil fields, as well as her control of the coal

and iron mines of Belgium and northern France, saved her from early defeat and prolonged the war. The Allies endeavored to reduce the shipments to Germany of Swedish high-grade ore (four or five million tons a year) by threatening to cut off Sweden's supply of coal and oil which were essential to her welfare; they curtailed Norway's exports of nickel, raw materials, and fish to Germany by rationing her food supplies; and they controlled Holland and Spain through exports of food and oil.

The purpose of this brief review has been to describe the two elements of international relations — the peoples and the geographic positions of states, and to indicate roughly how they accelerate, retard, or divert the course of international affairs. But there has been a further object in view, namely, to set forth the relations of the influence of minerals on world affairs to the other influences exerted by the factors described. It seems clear that among color and form, language, religion, intelligence and initiative of peoples, and among accessibility, topography, climate, and plant, animal, and mineral resources of countries, the features that stand forth above all others in their effect on the affairs of nations are human intelligence and initiative, climate, plant and animal resources, and mineral deposits. A remarkable narrative of the influence of particular minerals on the evolution of nations, their avarice for territory, their development of industries, their attainment of wealth and power, their contest for leadership or domination, and their future position in the world — in short, an account of the strategy of minerals, will be found in the following pages.

CHAPTER II

THE SHIPPING CRISIS

J. E. Spurr[1]

America as a factor in furnishing supplies to the Entente Allies — Indiscriminate submarine campaign Germany's answer — American problem becomes one of ships — Creation of the Shipping Board and the Emergency Fleet Corporation — The shipping crisis — Temporary expedients — Curtailment of import trade, depending on increased domestic production of raw materials — The programme as related to ores — The organization and the problem — Patriotic acceptance of reduction of business — Saving of ship efficiency equivalent to saving of ships — The ballast and backhaul arguments — Problems of Allied and neutral shipping — Choice between necessities — Success of the programme — Passing of the shipping crisis — Germany rebuilding our merchant marine.

When the ruling military caste of Germany were finally ready, in 1914, to carry out their plans for conquest and domination, they had prepared scientifically for swift victory and permanent ascendancy both by land and by sea. By land the marvelous Prussian military machine which had been built up patiently since the days of Frederick the Great apparently assured a swift victory against clumsy Russia and inferior France. By sea, for the first time, the German war lords could see their way clear. England, with her vast navy and her determination to remain mistress of the seas, was not expected to become an active participant in the swift struggle that should dispose of France. But if she should? For this problem and eventuality three separate answers had been prepared. First was the German high-seas fleet, built up to a strength second

[1] United States Shipping Board.

only to that of England; the war was postponed until the Kiel Canal could be finished, so that this great fleet could emerge at any time from its secure shelters in the Baltic into the North Sea, to harry the coasts of England and wage successful war upon detachments of the British fleet, and then take refuge if odds became too heavy or when refitting became necessary. Second was the air navy — the Zeppelins, worked out on a gigantic scale by Germany alone and formidable to naval and land forces alike. The third was the submarines. These three were all excellent answers to the possible British naval menace. Of America there was no question. A peaceful, industrial, loosely knit and loosely governed country, electing a new presiding officer every few years, a land of many races, the home of fads and quixotic and impracticable schemes (such as universal peace), a land where the watchword was "Success" and success meant dollars — surely that country could be left out of the reckoning until the time came to complete the German domination.

The first great disappointment of Prussia was that England should hurl herself into the conflict without waiting for the moment chosen by Prussia — not on account of her land forces, for the Prussian war-chiefs considered them negligible, but solely on account of her sea power and the blockade which she might, and did, establish on German ports, to the consequent paralysis of German commerce. Nevertheless, the Germans were ready with their three solutions to the problem, and all these arguments were at once put into effect. The air fleet proved a failure, fit only to vex London and English country towns and for savage and meaningless killing of women and children. The German navy also proved a failure. Of the three weapons which Germany

had ready, the submarine proved to be the most efficient and the most astutely chosen. It inflicted repeated losses on the enemy fleet, but to the final chagrin of the Prussians it could not break the naval front and power of the British. More and more it became evident to the Prussian conspirators, and to a duped and degraded German people, that the war was to be on land, and that their first and last victories must there take place.

With the prolongation of the war supplies of food and raw materials began to run short in Germany; the English blockade continued effective, and the necessity for relief became great. It was at this time that America began to usurp the place of England in the dislike of Gott's elect. The war increased enormously the trade of America with England and France, and, on account of England's blockade, cut it off from the Central Powers. Supplies to England and her allies consisted of food, raw materials, and munitions. England's fleet prevented Germany from receiving like supplies from America, although the situation grew so desperate that Germany built and sent across the Atlantic giant submarines which returned with cargoes of the materials most urgently needed — copper, nickel, rubber, etc.[2] Added to that, there arose in America a violent and growing popular feeling against Germany as the proof of her astounding moral degeneracy became more incontrovertible. In effect, therefore, America ranged herself among the natural enemies of Germany

[2] It is possible that the main purpose of dispatching German submarines to our shores in 1918 was to take on in some secret manner supplies of certain raw materials, like copper and steel-hardening metals, supplies which were exhausted in Germany, and that the sinkings of merchant ships on our coast were only an incident.

long before she declared war, and the supply of enormous amounts of food and war materials to the Allies represented more largely America's contribution to the war than a matter of business and profit. This was, however, by no means Germany's analysis of our motives; and it was this failure of Germany to read the complex American psychology which brought about the condition that furnishes the title of this chapter.

Given a nation grown conscienceless, as Germany had become, with the idea of any possible equality of rights and treatment between Germans and non-Germans definitely abandoned and forgotten, there was but one answer to the British blockade and the supply of the materials of war to the Allies by America. It must be stopped in any possible way. The theory that the end justified the means had been frankly adopted. International law had long before been officially thrown to the winds, and the principles of humanity had been renounced as regarded non-Germans. The Divine mission justified all. Only one consideration deterred immediate attack on American steamships and commerce — the fear that America might resent it to the point of entering the war.

There were some in Germany who thought this was possible and many who insisted that it was not. After a few experiments, such as the sinking of the *Lusitania*, it appeared to Germany that these plans would work. America was being punished, but she would not fight. The submarine campaign persisted, multiplied, and became effective. Not only American ships, but ships of other neutrals, were sunk wholesale; the commerce of a world which did not serve the needs of Germany was attacked regardless of the loss of life of non-combatants; indeed, many such losses were deliberately brought about

to emphasize the ruthlessness of the German campaign. The plan was succeeding, so German chiefs believed and the fatuous German people were told, and the enemies were being starved out with their own weapon, the blockade. At the rate of sinking of ships the war would be won in a few months. America was not in a position to continue for long sending ships or supplies, and to send men was out of the question; America was already reduced to acquiescence and must take orders from Germany. And accordingly orders, insolent orders, were issued, permitting America to dispatch certain ships, in certain ways, at certain times, and putting the United States under German direction and a German protectorate. And then, as had happened several times before in the war, the limit of Teutonic intelligence having been reached, an unintelligible thing happened; America declared war on Germany — at a time when Germany was in the ascendancy, and when, according to all Teutonic rules, America should have kept under the lee of the winning side, or at least stood apart and not interfered. The American people went to war, throwing their dollars, their determination, and their lives into the conflict for an ideal as to the rights and freedom of all nations, an ideal which they had finally worked out and weighed to their own satisfaction. With the full force of the nervous American composite character, they determined that the results of three hundred years of conflict for greater liberty and more equal opportunity should not be sacrificed. Nor would they allow democracy in France to be crushed, nor in England; and the newborn chaotic democracy in Russia should be given a chance to develop and organize.

Full and free as this decision was, it was slow and late in coming. America had hoped that all would turn out

differently, with a childlike faith in the ultimate honesty of all nations, now decisively shattered. Everything must be done at once and on a grand scale. The situation was desperate. Men were needed, and arms, and food, for America and all her comrade nations — and ships. *And ships.* The most marvellous and most difficult military undertaking of history spread itself out as the only solution for America and for the world. Beside the idea of this undertaking Germany's colossal military plans for conquest became puny. From the New World to the Old — from the Colonies, so to say, to the Mother Countries — a bridge of ships three thousand miles long must be built and maintained, and over this must pass sufficient food and munitions to supply our allies. And it became clear that this was not enough. We must send men, soldiers, millions of them, across the Atlantic, and beat the German beast into submission within its own frontiers. And we had neither soldiers nor ships. We had never had any use for soldiers and did not approve of them. We did not approve of war. And for many decades our energies had gone into the upbuilding of our own vast domain, so nearly self-sustaining and so nearly independent of the world's commerce, and we had left the fetching and carrying by sea to those cramped European nations who had to depend on foreign trade for existence.

In earlier days, before the railroads opened up the vast possibilities of internal enterprise and travel was so much easier by water than by land, American sailing ships and American sailors pervaded the globe, and the rude American navies dominated the seas, East and West. But the era of steamships overtook us when American enterprise was directed west instead of overseas, and only an occasional voice pointed out the ad-

visability of building an American merchant marine, if only as a means of national insurance. Commercial obstacles arose which made the creation of this fleet unprofitable. Ships could be built and manned more cheaply in other countries, and Congress ruled that these could not fly the American flag, even if they were owned by American capital. Government encouragement, favors, and subsidies, extended to the mercantile fleets of other nations, were denied to our merchants; we were daily growing more international, and we could use the ships of other nations and charter them with their crews if need be.

It was not, however, the lack of ships that so seriously menaced this country when the war broke and the shipping crisis became the most important factor, although that lack was serious enough; it was the lack of shipyards and builders. It now seemed that overnight, almost, these deficiencies had to be made good. Docks must be built, designs perfected, vast supplies of material obtained, an army of skilled workmen created, and without a moment's delay. The President looked to the Shipping Board to work out the problem, and an Emergency Fleet Corporation within the Shipping Board was organized to build, or cause to be built, the necessary fleet. It was a fight against time, with the submarine campaign in full course and the trans-Atlantic fleet, so necessary for all our hopes and plans, dwindling daily. As had so often happened in the past, our strong American individualism — our greatest American asset — at the outset locked and neutralized and delayed. What was happening to our boasted American efficiency? As was happening all along the line, in our other sudden war problems, it was crystallizing into shape; it was being smelted out of diverse and

refractory ores, amid discouraging conditions of turmoil and delay.

Soon it was seen and acknowledged that even with the wisest direction it would take time to organize and build a fleet, and more time to build fast enough to neutralize and surpass the rate of submarine sinkings. Emergency devices were needed to fill the gap created by our failure to realize in good time what eventually we would have to do. Nearly all the ships that sailed the sea were in the hands of our allies or of friendly neutrals. German and Austrian ships, which had been interned in American waters by the score, were refitted and put into the scale against their builders. Neutrals needed from the United States food, raw materials, and financial assistance, so exchanges and deals were made whereby the United States obtained fleets from Norway and from Holland. Brazil contributed the German ships that she had interned in her harbors before the declaration of war, and Japan moved ships from the Pacific to the Atlantic.

The shipping crisis, however, still existed, acute and threatening. "Ships, ships, more ships," was the message sent back by the commander of our little army in France; men, money, food, and even munitions were ready, but we had not ships enough to carry them. And as a further measure to meet the crisis, in part, a drastic and heroic expedient was proposed and finally decided on by the Shipping Board and authorized by a special proclamation of the President. The full significance of this expedient would be astonishing to those German psychologists who had so carefully analyzed American character and decided that commerce and profit were the first and last aim of the Yankee nation. The idea, in brief, was to take from our foreign trade all

the ships that could be spared — to cut our commerce down to the extreme limit of safety, leaving only so much as was necessary to supply us with war essentials that we do not produce, and to place those ships in line as a part of the trans-Atlantic shipping bridge which was to bring us nothing but honor and liberty. When first conceived, the utility of the plan was apparent, but the Government hesitated to attempt it, fearing that a thing so violent and unprecedented could not fail to arouse uneasiness or antagonism among our business men and might fail in the execution. Chairman Edward N. Hurley of the Shipping Board decided, however, to put the plan into effect, and commissioned Dean Edwin F. Gay of the Harvard School of Business Administration to work it out, in conjunction with the War Trade and War Industries Boards. A corps of experts and statisticians was hurriedly organized to work out such programme as would be feasible, to cut wherever possible, as deep as possible, but without crippling any essential war industry, in order that in conserving shipping our supply of essential raw materials might not be jeopardized. The investigations and programmes outlined covered all exports, both raw and manufactured materials,[3] but the scope of this book covers only the ores and minerals that our Eastern furnaces, smelters, and factories, mainly located near the Atlantic seaboard, had always imported in large quantities from overseas. These were to go into the building of ships, arms, munitions, and other essential war fabrications. It was on the maximum output of these eastern industries that the maximum efficiency of the war de-

[3] For a complete discussion of these programmes relating to all raw materials, see, in this series, Louis E. Van Norman: *War Time Control of Commerce.*

pended. The delicacy of the situation is at once realized, and the natural dismay of some of those industrial captains who, now that it was a question of war rather than business, were bending every energy to supply the country's needs.

The study and framing of the import restriction programmes for ores, minerals, and metals were assigned by Dean Gay to Dr. C. K. Leith of the University of Wisconsin, who associated with himself the writer; Pope Yeatman of the War Industries Board became a third member of the committee, representing that Board. To this committee there were later added several associate members, including representatives of the Geological Survey, the Bureau of Mines, and the War Trade Board, and an auxiliary technical staff was built up. Close relations were established with all departments of the Government that were interested in ores and minerals. This work was greatly aided by the Joint Information Board of Minerals and their Derivatives, which was organized at about the same time, with Pope Yeatman as Chairman and Edson S. Bastin of the Geological Survey (also an associate member of the Shipping Board committee) as Secretary. To this Board some thirty or more distinct Government departments and bureaus appointed representatives, and a more complete coördination of effort among the Government agencies interested in ores and minerals (each from a different point of view) was brought about.

There has been much criticism of duplication of work in Washington, and, among other things, of duplication of work on ores and minerals, and in the beginning this was true. The duplication, however, became less and less, until at the termination of hostilities there was comparatively little of it, and all those engaged in the

work maintained a constant effort to prevent it. The earlier duplication, and more than that, the fear of duplication, however, established the habit of criticism and caused those newly plunging into Washington or watching the game from the sidelines to exaggerate the symptoms. It was not necessarily duplication, for example, that a dozen or twenty different boards, committees, or bureaus were interested in the subject of tin, or chromium, or manganese, and were making special studies and detailing special men to these studies. As a matter of fact, if all these boards, committees, and bureaus had not been so interested and active, they would have been neglecting their work, for each approached the subject with its own special function in view. The thing that was necessary was that all should work in harmony and that the different specialists working on the same subject should form unofficial committees, to divide up the work and see that there was no real duplication. This coördination of work was partly accomplished by the Joint Information Board, and it was still further accomplished by informal committees or frequent interbureau conferences on special subjects, such as manganese, pyrite, mineral fertilizers, graphite, and so on down the list of war minerals.

The United States is one of the richest countries in the world in minerals, a circumstance which more than anything else has enabled her to rise rapidly to wealth and power — the power for good or evil. Coal and iron in vast quantities have put her at the head of the steel business, most vital of industries, and by her vast stores and produce of copper she controls to a large extent many of the more intricate modern manufactures, such as those involving the use of electricity. Certain essential ores, however, are found in insignificant quantities

in the United States or even in North America — for in all this the whole of North America, except Mexico, must be and has been considered one mutually friendly economic domain; and certain other essential ores found in the United States are inferior in quality and perhaps in quantity to those found overseas, so that commercially they have not been able to compete with them. The necessities of the war called at first for larger, rather than smaller, imports of these essential minerals, which included especially ores used in steel making and steel hardening, such as manganese and chromite; materials used in making explosives and in fertilizers, such as pyrite, used in making sulphuric acid, and nitrates; and a variety of other mineral supplies, such as graphite (used in making crucibles for crucible steel manufacture and for a wide variety of other uses), the finer clays, natural asphalt, monazite, nickel, mica, special low-phosphorous iron ores (used for certain special steels), copper metal and copper ores, ores of aluminum (bauxite), cryolite from Greenland (used in aluminum manufacture, for enamelling, etc.), abrasives, and grinding pebbles.

It was simple to cut off the importation of building stones which had gone on from many foreign countries, for not only could these be dispensed with as non-essential to the war, but building was halted by the war to such an extent that our domestic building-stone industry was paralyzed. It was easy even to restrict rigorously the importation of gypsum from Nova Scotia when it was evident that the barges employed in this trade were absolutely needed for carrying coal. But in dealing with materials used for making steel, munitions, and explosives the task was difficult, and these were being imported in large quantities and from long dis-

tances. Practically all the manganese (99 per cent.) had always been imported by our steel makers — mostly from southern Russia before the war, then largely from India, and finally largely from Brazil. To reduce the shipping needed to bring in manganese a careful canvass of requirements was necessary, as well as a survey of domestic manganese mines and what they could be made to produce to make up whatever could be cut off from the imports. A survey of the possible ouput of American mines was the least difficult part of the problem. In the way of the desired and theoretically possible production stood actually existing lack of railroad transportation facilities, an appalling shortage of labor, inability to get new equipment, and finally, in many cases, insufficient inducement for private enterprise to embark on war-mineral ventures; and the Government had no immediate way of increasing production to the point desired other than through private enterprise. Moreover, the domestic ores were of lower grade, and their use required changes in the practice and minor changes in the equipment of the steelmakers, and, finally, a new and more rigid economy in the use of manganese.

Of chromite, one of the most essential of the war minerals, we have always produced little in this country, although in the early part of the nineteenth century the mines of Maryland and Pennsylvania produced the larger part of the world's supply, which at that time was small. After chromite was discovered in Turkey by an American, however, the world's center of production moved to the region of the Ægean Sea and later to two new centers — Rhodesia in Africa, and New Caledonia in French Oceania, and it was from Rhodesia and New Caledonia, both long hauls, that the bulk of our chromite was coming when the war began. The early events of

the war restricted our supply to the more remote source, New Caledonia. The problem of decreasing the shipping needed to supply this essential war material lay in stimulating domestic and Canadian production, which was done by patriotic propaganda, by judicious raising of prices, by investigation, encouragement, and guidance by mining engineers sent out by the Government, and by the investigation and development of overseas deposits from which the hauls were shorter than from those already developed. Considerable deposits of chromite were found and opened up in Brazil by private companies, and investigations were made in Cuba by the United States Department of the Interior revealing certain possible supplies. A plan to economize the use of chromite was prepared and adopted, steelmakers agreeing to use a certain maximum in their practice; and magnesite and dolomite, both abundant in the United States, were to a great extent substituted for chromite as a refractory in steel making. By these various devices it became possible to cut off very largely the long haul from French Oceania and, with the stocks of overseas ores already on hand, to restrict the sources of supply to the Americas.

The adoption of the plan for the reduction of imports depended upon its acceptance by several independent war boards (and as our war boards were for the most part raw and only partly systematized organizations, this was not a simple matter), and, moreover, upon the consent and coöperation of at least a controlling part of the great war industries affected, for if these had thrown up their hands and refused to consider and guarantee production of our essential war materials without these supplies of raw materials from overseas, it would have been impossible to put the plan into effect. The most potent

argument, of course, was at hand and in evidence. The ships were not available. The discovery of this fact, the repeated failure to secure ships for importing ores, the threat of the failure of even the minimum supply on account of lack of system for disposing of the shipping that was available, warned our manufacturers of the necessity of a system that should tend to assure them a minimum supply and enlisted their coöperation in plans for economizing these materials in manufacture and for stimulating the domestic production to take the place of imports.

But some further statement is warranted. It would be foolish to declare that unworthy motives did not exist here in America as elsewhere, in high and low places, even during the time of the Nation's greatest need and test. Certain men habitually think of their personal business before they think of their duty to their country; and some of them consistently maintained this attitude, and the ramifications of the profiteering spirit extended throughout the Republic. Among these men were some who were good, temporarily, because it was in their interest to be so, who were not to be trusted far, and on whom we could not depend for any settled policy. In a country so poisoned by Prussianism as America was when the Great War broke out it could not have been otherwise. But it is cheering to record the conviction that the profiteers were vastly outnumbered by the business men who, under the strain and test of the times, went over their accounts and decided to put honor and duty above fortune. And where restriction of imports injured private business, it is pleasant to recall that in nearly every case the injured party, once assured that it was indeed to the Nation and not to competing firms that he was sacrificing, made the sacrifice cheerfully and

helpfully. Deserving of note is the case of the chief importer of pyrite from Spain, who was a member of the committee of pyrite consumers appointed to advise the Government as to minimum requirements from Spain, and who himself proposed to this committee a sweeping cut which entirely met the requirements of the Government and incidentally destroyed his own business; and who devoted his time thereafter largely to seeing that the restrictive programme was successful, as it was. Many organizations whose business had been prosecuted with typical American aggressiveness agreed cheerfully to cut their business in two or even more rigorously, and assisted in the cutting. In short, this was the strongly prevailing spirit, and the heroism of the average American business man at this juncture deserves to be recognized and chronicled.

Nevertheless, the theory and effect of the campaign to bring about the maximum ship utilization was not without its challengers. This maximum utilization involved not only a cutting off of the maximum tonnage of imports from overseas, but an increase in ship efficiency by other means. For ores that must be imported by water the length of the haul had to be considered, and the longer hauls were restricted or eliminated in favor of the shorter, so that a ship could make more round trips and deliver a greater tonnage within a given time. The shipment of manganese from Cuba, for example, was encouraged to the utmost, whereas that from Brazil was rigorously limited, and that from India was banned. Salt for curing fish was admitted under certain conditions from the West Indies, but was cut off from the Mediterranean.

The elements of the problem of ship efficiency, though simple, were apparently not so simple that they could be

understood by all shippers. As all the ores are heavy, they are loaded as the lower cargo in a mixed cargo, for the lighter materials must go on top. As a result a universal claim arose that these ores were needed as ballast, without which the ship could not sail, unless she were ballasted with stones at much expense and with loss of time. The allowance of this claim would have effectively put an end to the programme of saving shipping by reducing mineral imports; for any proportion of the total cargo capacity could be and was categoried under the head of ballast, and many full shiploads of ores on which no top loads of lighter materials were carried were thus classified and were strenuously presented for exemption on this ground. Ballast became the open sesame of the hopeful shipper and the *bête noir* of the patient but persistent parriers of arguments in Washington. One shipper contended that mineral water in bottles was the ideal ballast. After a special investigation of the ballast question made by F. W. Paine of the staff, it was established that ballast is practically unnecessary in any cargo, as all steamers are provided with water-ballast devices and can sail empty, and many of them do so sail by preference. Such ballast as they carry is really heavy bottom cargo, carried for profit and at a substantial freight rate. "Stones and pebbles" carried as cargo turned out to be valuable dressed stone or flint pebbles which are used for grinding in tube mills and which bring a high price in the United States.

Equally vexatious and fallacious was the argument of backhaul. It was represented that many ships would return to the United States without full cargo unless they were allowed to bring certain ores or minerals, and that therefore there would be no gain in restricting their importation. This claim, of course, took no note of the

time consumed in loading and unloading the cargo, or, frequently, of time consumed in putting into additional ports for that purpose. Evidently such operations involved a very large loss of ship efficiency. Detailed studies were made of the facts in certain trades between certain ports and of the actual time consumed in loading and unloading each of a number of ships, and it was found that every round trip was appreciably lengthened by a full return cargo of the ore or mineral under study, often by 50 per cent. or more; so that the elimination of this return cargo (which was unnecessary for carrying on the war) would be equivalent to increasing the fleet available by the amount indicated. As a practical matter, and not as a pretext, there would be, of course, no question as to this principle. Now and then, in order to save time and increase its efficiency, a steamer bringing nitrates from Chile in a rush returned empty without waiting for the coal which it might carry back. Nevertheless, the pretext was perennial and was constantly revived by shippers at home and abroad, and even by the missions from foreign Governments.

Other obstacles presented as opposing arguments were that the commodities were carried on Allied or neutral ships and not in American bottoms, and that they were being carried in sailing ships that could not be used for the trans-Atlantic voyage. To the first contention the answer was, of course, that the Allies were working on a common programme, and that every one of their ships that was released contributed as much to the war programme as an American ship; and that neutral ships, deprived of the trade of carrying unnecessary or dispensable minerals to the United States, would naturally get into some trade that had been judged to be indispensable, even if not into the trans-Atlantic trade, and

would thus release Allied shipping for direct war service. To the second argument the answer was, similarly, that any craft, sailing or otherwise, large or small, if cut off from an unnecessary trade, would take up a necessary trade, such as that of bringing sugar from Cuba or cargoes from South America or even from Australia, and thus release the larger steamers to strengthen the trans-Atlantic bridge.

In the attempt to restrict to the minimum the importation of certain ores from certain regions, it appeared at first that not enough shipping was available even for this, and problems arose as to which to carry first out of two or more essentials. Copper and nitrates, for example, were both needed from Chile, but both could not be brought as rapidly as needed on account of the limited shipping available in that quarter. It became necessary, therefore, to restrict the copper cargoes to commodities high in copper — copper metal, matte, and concentrates, and not carry the ore, and to give preference to nitrates even over these, for although the United States produces a vast amount of copper, it is not yet a great producer of nitrates.

The programme for restricting mineral imports resulted in the cutting out of the importation of about a million tons of mineral products, or about 40 per cent. of the amount previously imported, and transferred to trans-Atlantic and other indispensable routes about 400,000 tons of shipping. Small as this tonnage is in comparison with the total shipping afloat, it yet represented a margin of safety without which we could not have carried through our military programme, in which every ship was utilized to the utmost.

In the months that passed after these programmes were put into effect, the calculations made were

abundantly justified. Efforts to economize consumption and to stimulate domestic production produced results surpassing the moderate estimates on which the programmes were framed, and even with the saving of imported tonnage mentioned above adequate supplies of our essential war minerals became assured. More than that, it became evident that further restriction of imports would have been possible for 1919, in spite of our increased production of war supplies, so that the programme for 1919 called for the elimination of 60 per cent. of our previous importation of ores. This work was accomplished entirely by the coöperation of private enterprise with Government programmes — a difficult and interesting feat. The mining engineers of the country had proposed to Congress a War Minerals Administration which would have given the Government the necessary control over domestic production, and it was indeed desirable that the Government's control should be more clearly defined and its weak points strengthened. In the meantime, however, American adaptability stepped into the gap.

After the crisis was passed Congress finally passed the Act creating a Mineral Administration,[4] and the President designated the Secretary of the Interior as Administrator the same day that the armistice with Germany was signed. With the cessation of hostilities, however, and the sudden termination of the necessity for piling up maximum amounts of war materials, the need for further stimulation of the war minerals practically terminated; in fact, the supply of some of the minerals of which there had earlier been a real or threatened shortage began at once to back up against the dam of a lessened demand.

[4] Quoted in full in the Appendix.

Thus the "shipping crisis" passed even before the dramatic termination of the war. Means of avoiding and destroying the German submarine were improved both in America and in England; and it became powerless to break our bridge to France, over which vast supplies and more than two million American soldiers had passed. The sinking of merchant ships still continued, although at a reduced rate, owing to the activity of the Allied anti-submarine craft, the bottling up of the submarine bases on the Flemish coast by the spectacular British raids, and other operations; but the shipyards of America kept turning out an ever-increasing stream of new ships, and Germany finally realized that her submarine campaign was the latest and greatest of her miscalculations. The rate of launching of new ships became equal to the rate of sinking, and from that point increased daily. As the Chairman of the Naval Consulting Board said at a dinner at this juncture: "The submarine is no longer a danger, it is only a nuisance."

Nevertheless, certain regulatory measures as to the utilization of shipping will probably have to be kept up for a little while. Gradually, however, we shall be able to spare ships to take up the foreign trade from which we have so heroically cut ourselves off, and then to increase it. Eventually we shall have a great fleet of ships released from war service and flying the American flag, and this fleet will carry our commerce into every sea and unite us ever more closely with our friends and allies who shall constitute the leagued democractic nations of the world. And it will be the Germans who have built this fleet for us, by launching their submarine campaign to sink what ships we had, bringing about, first, our entry into the war, and, second, our great shipbuilding renaissance.

CHAPTER III

MINERAL FUELS

C. E. LESHER[1]

Fuel a prime necessity in war and peace — Production of coal a measure of industrial activity — Reserves of coal — Factors limiting production — Control exercised by labor and transportation — Causes of coal shortage in 1917 — Work of the Committee on Coal Production — Establishment of Government control — Problems considered by the Fuel Administration — Complications and importance of distribution — Zoning system; budget; preferred consumers — Mobilizing the army of mine labor — Strategy of distribution of supply — Conservation of fuel — Increase in production of petroleum unequal to increase in demand — Future supply of oil limited — Need of foreign reserves.

Fuel looms large among the Nation's war minerals, whether it is considered as fuel for man's own house or fuel for his factory or other place of industry; and of fuels coal bulked largest in the Great War. Coal and petroleum, the gifts to this age of past geologic epochs, lie buried beneath the surface, available at different places in different degrees of profusion and richness for the use of civilized mankind. Not all parts of the globe possess deposits of fuel; the United States is fortunate in having a large share of the world's reserves of mineral fuel of excellent quality in deposits which are so favorably situated that they can be cheaply extracted. The only considerable deposits of anthracite and the best and richest beds of bituminous coal in the United States are in the eastern part of the country, convenient to the region of our greatest industrial activity. The industries of the Middle West, centering about the heads of the

[1] United States Geological Survey.

Great Lakes, are yet dependent in large measure on the high-grade bituminous coals of the eastern or Appalachian belt. In the region west of the Mississippi the coal produced is but 12 per cent. of the total mined in the country, but the petroleum is 85 per cent.; on the Pacific Coast coal is almost negligible, for petroleum and natural gas turn the wheels of industry. No one need fear the untimely exhaustion of the underground reserves of mineral fuels in this country.

The easternmost portion of the Appalachian region contains the highest grades and the most valuable deposits of bituminous coal and anthracite. From northern Pennsylvania to central Alabama the area underlain with bituminous coal extends generally northeast and southwest, with the anthracite region a small isolated area in eastern Pennsylvania. The coals coming from this field are for the most part of high grade, ranging from the so-called "smokeless" or low-volatile coal of the Pocahontas and New River fields of West Virginia, the Georges Creek of Maryland, and Somerset and Clearfield districts of central Pennsylvania, through the high-volatile gas and coking coals of Alabama, Tennessee, Virginia, southern and central West Virginia, eastern Kentucky, and the Pittsburgh, Connellsville, and adjacent fields of western Pennsylvania, to the lower-grade steam and domestic coals of Ohio. About 65 per cent. of the total production of bituminous coal of the United States comes from this general region.

A large portion of the farm lands of Illinois and portions of western Indiana and western Kentucky are underlain with medium-grade bituminous coal, and about 22 per cent. of the output of the United States comes from this area. West of the Mississippi, in the area from north-central Iowa through central and western

Missouri, southwestern Kansas, into Oklahoma and Arkansas, are deposits of medium- and low-grade bituminous coal from which the annual output represents less than six per cent. of the total for the country.

In the northern Great Plains region in western North Dakota, eastern Montana, and northeastern Wyoming are vast reserves of brown lignite and of sub-bituminous coal. In the Rocky Mountain region, in scattered areas in Montana, Wyoming, Colorado, Utah, and New Mexico, are large deposits of coal ranging in quality from brown lignite to anthracite, and in Washington and to a lesser extent in Oregon and California are areas of coal land of both low and medium grades. The production from these fields west of the 100th meridian is but seven per cent. of the total, but the reserves, although of much lower grade, are greater than those of all the remainder of the country.

Fuel is a prime necessity; by denying the use of fuel for five stormy days in January, 1918,[2] the Government stopped the wheels of industry. Coal transcends iron and steel in importance, for it enters into the daily life of all. Coal, made into coke, converts iron ore to metal and brings the metal to shapes that finally become the essential parts of ships, shells, or automobiles; coal runs the ships and the railroads — the great systems of transportation that have made the world so small. The railroads in the United States use about 27 per cent. of the soft coal here produced; the manufacturers, about 55 per cent.; domestic users, 12 to 15 per cent.; and the remainder is taken by steamships to foreign countries.

[2] The "fuelless days," eight in number, decreed by the United States Fuel Administrator by order of January 17, 1918, were January 18-22, and the three following Mondays, January 28, February 4, and February 11.

Coal is not sold except for present-day use; no salesmanship can induce a consumer to buy more than he thinks he needs either for immediate use or for storage in anticipation of difficulty in obtaining a supply. By the opening of new mines and the development of old ones the capacity of the mines and miners of the country to produce coal has so far kept pace with the country's needs and is now greater than the capacity of the railroads to transport the coal. The production of coal is, therefore, from year to year, an index to the current industrial condition of the country.

The increase in industrial activity since the beginning of the Great War is shown by the increase in the production of soft coal from 422,000,000 tons in 1914 to 552,000,000 tons in 1917 and 585,883,000 tons in 1918, a gain in four years of 163,000,000 tons, or over 38 per cent. These figures indicate the immense value of coal to the country and our ability to speed up production to meet an unprecedented demand. Conservative estimates place the present capacity of the bituminous coal mines of this country at nearly 700,000,000 tons in a year of 304 working days, nearly 115,000,000 tons above the production in 1918. This reserve power of production is the present factor of safety in our coal supply.

With ample underground reserves of coal and a sufficient capacity of developed mines an increase in production must depend upon increased labor and transportation. Only an insignificant part of the coal mined is used at the mines; nearly all of it must be loaded on railroad cars for shipment, for most of it is consumed at points far from the mines. Mine labor has been sufficient, so far, to meet the demand, for in but few coal fields, and those not the most productive, has the available labor force during the last three years or at any

other time been able, or if able, willing, to work six days a week in producing coal. In 1914 there were employed in the United States in mining soft coal 583,506 men, who worked an average of 195 days to produce 422,000,000 tons; in 1917 there were so employed 603,687 men, who worked 243 days to produce 552,000,000 tons. The average production per man in 1914 was only 724 tons, but in 1917 it was 915 tons and in 1918 it was almost 970 tons. The average daily output per man in 1914 was 3.71 tons, as against 3.78 tons in 1917; in 1915, however, the average daily production per man was 3.91 tons, and in 1916 it was 3.90 tons. The large gain in 1917 over 1914 was due to the greater number of days' work done at the mines during the year, and the most promising means of further increasing the annual production lies in still further increasing the number of days' work. It is on the basis of six days a week that most of the world's work is done.

The coal brought to the light of day by the mine cars must be at once loaded on railroad cars and sent to the consumers, for few mines are equipped to store mined coal and not many are so situated as to make storage feasible. Coal on the ground at the point of production, moreover, is of no more benefit to the far-off consumer than coal under the ground. The rate of production could be increased somewhat by storing coal at the mine, because it would speed the turn-around of the coal cars; for this reason storage at the mine has had some advocates, but it has been adopted at only a few places in the United States.

The number of empty coal cars that the railroads place at the mines determines the outside limit of hours per day or days per week that the miners can work, and the number of hours per day and days per week the miners

actually work, even when empty cars are available, is a large factor in production.

In 1914 and 1915 and, in the greater part of the country, in the first three months of 1916 the production of coal, both anthracite and bituminous, was limited by lack of market; industry was not demanding fuel at a rate beyond that at which it could easily be mined and transported. In October, 1916, there arose, together with a marked increase in the demand for bituminous coal, a shortage of railroad coal cars. The consumers, facing the possibility of a short supply for the winter, started to buy and bid for coal in a scramble that amounted to little less than a panic. In the winter of 1916-17 the price of coal at the mines in some districts rose to nearly five times the normal price, and during the ensuing months, or until the first of July, 1917, coal not under contract went to the highest bidder, whoever or wherever he might be. The normal movement of coal between producing and consuming districts was interrupted; established trade relations were forgotten in the dual effort of the producer to sell his product to the best advantage and of the consumer to provide the largest possible security against what he believed to be impending disaster. In many factories the cost of fuel per dollar's worth of finished product is so slight that the manufacturers bought coal regardless of price, and many of those who had contracts, whether at high or low prices, piled up reserves, even in quantities far beyond their actual needs.

The principal cause of this abnormal condition was the congestion of the railroads by the tremendous and unexpected movement of heavy freight from manufacturing centers to both seaboards, principally to the north At-

lantic ports. The overseas business with the Allies, which steadily grew in 1916 to mammoth proportions, was more than the railroads or the ships could easily handle. Cars of all kinds stood by thousands at Atlantic ports, and the flood of immovable freight backed up to the mouths of the coal mines. Speculation in coal was rife; carloads were bought and sold and passed around the country for weeks before unloading, and a great number of railroad cars were thus tied up. Consumers bought coal they could not unload and delayed unloading what they had. The shipment of coal to distant and abnormal markets kept cars in service months instead of weeks or days. The movement of coal from Illinois to Connecticut, from Ohio to Baltimore, and from Arkansas to the Twin Cities was a needless waste of transportation.

In the spring and summer of 1917, mine labor, which had entered into a two-year wage agreement with the operators to be effective until April 1, 1918, became notably restless. The operators were profiting to an extent not expected in the spring of 1916 when the agreement was made, the cost of living was mounting, and lack of cars was interfering with the regular running of the mines in many districts. Many operators made voluntary advances in wages to the miners; others attempted to hold to the established scale, and thus assisted in unbalancing wages and in increasing the general unrest of the miners. The wage agreement of 1916 was made in accordance with the custom of long standing whereby the operators and union miners in the so-called central competitive field, comprising the union districts in western Pennsylvania, Ohio, Illinois, and Indiana, enter into two-year wage contracts as of April 1 of the "even" years. Other union and non-union dis-

tricts during the summer and fall of 1916, also in accordance with their custom, followed the lead in wage contracts and scales set by the leaders in the central competitive field. In the fall of 1917, six months before this agreement expired, the miners asked for advances in wages, and after consideration by Harry A. Garfield, the United States Fuel Administrator, and with the approval of the President, a new contract was entered into (effective from November 1, 1917, until the promulgation of peace) covering all bituminous fields in the United States. This new agreement provided general advances in the rates of pay to day labor and to miners, the general average of which was estimated as equivalent to 45 cents per net ton of production. The operators in union and non-union fields were permitted by the President to add this sum to the selling price of their coal at the mines when they paid the authorized advances in wages.

When the United States entered the war in April, 1917, the Government became directly concerned in the production and movement of coal. The Navy needed coal in vastly greater quantity than before; the contractors for war supplies must have coal; the various Federal institutions — such as post offices, Indian schools, and arsenals — must be supplied; the public utilities — the railroads themselves, on which public and private business depends — must be provided with fuel; yet coal, though mined in ever increasing quantity, was going mainly to the highest bidder — the prosperous manufacturer. Labor unrest, high prices, shortage of means of transportation, increasing demands, and wild scrambling for supplies, caused a popular stir — a questioning of causes and motives, a suspicion of unfair practices, which grew as the spring and summer of 1917

passed and produced fruit ripe for the plucking by the politician.

In April, 1917, the Committee on Coal Production of the Council of National Defense was organized.[8] At first the power of this Committee was limited to that of suggestion only, and two months after its organization the progress of events took away even that power. During the period of its activity, an activity which, though brief, was intense, this Committee was instrumental in settling a number of labor disputes, in arranging to procure supplies of coal for the Government, and in organizing the coal operators for coöperation with the railroads to facilitate transportation. The one thing necessary to correct the underlying difficulty with coal — a central control of the industry and of the railroads — was denied to the operators and railroads by law. Nevertheless, the railroads, through the Car Service Commission of the American Railway Association, and the operators, through the Committee on Coal Production,

[8] The Committee on Coal Production as originally constituted, was as follows: F. S. Peabody, Chairman, President of the Peabody Coal Company, Chicago; E. J. Berwind, President of the Berwind-White Coal Mining Company, New York; W. W. Keefer, President of the Pittsburgh Terminal Railroad and Coal Company, Pittsburgh; Van. H. Manning, Director of the United States Bureau of Mines; John Mitchell, Chairman of the New York State Industrial Commission, New York; C. M. Moderwell, President of the United Coal Mining Company, Chicago; E. L. Pierce, Vice-President of the Semet-Solvay Co., Syracuse, New York; Erskine Ramsay, Vice-President of the Pratt Consolidated Coal Co., Birmingham, Alabama; George Otis Smith, Director of the United States Geological Survey; James J. Storrow of Lee, Higginson and Company, Boston, Chairman of the Massachusetts Committee on Public Safety; H. N. Taylor, Vice-President of the Central Coal and Coke Company, Kansas City, Missouri; S. D. Warriner, President of the Lehigh Valley Coal and Navigation Company, Philadelphia; J. F. Welborn, President of the Colorado Fuel and Iron Company, Denver; Daniel B. Wentz, President of the Stonega Coal and Coke Company, Philadelphia; and George W. Reed, Secretary, Chicago.

accomplished many things that made the conditions better.

Late in June, at the invitation of this Committee, the coal operators met at Washington and voluntarily agreed to reduce the prices of bituminous coal from different fields to prices ranging from one-third to one-half of those then prevailing. The memorandum given to the press on June 28, 1917, following the three-day meeting of the operators, described the agreement as follows:

As a result of the conference between the mine operators, the Secretary of the Interior, Federal Trade Commissioner Fort, Chairman Peabody and the Committee on Coal Production of the Council of National Defense, the following reductions were made to go into effect July 1 next in the prices of coal. This, according to the statement of Director George Otis Smith of the Geological Survey of the Interior Department, will effect a reduction to the consumers east of the Mississippi of 15 million dollars a month, based on the output of free coal in May of this year. These prices are maximum prices per ton of 2,000 pounds aboard the cars at mine, pending further investigation. These prices do not affect in any way contracts in existence or sales of coal for foreign or export trade.

The operators tendered to the Government a reduction from these reduced prices of 50 cents per ton for coal that the Government may need.

No action was taken upon anthracite prices because of the fact that these prices had already been acted upon by the Federal Trade Commission.

Twenty-five cents per net ton was fixed as the maximum price for coal jobbers' commission with only one commission, no matter how many jobbers' hands the coal may pass through.

On account of an inadequate representation of operators west of the Mississippi, no maximum prices were fixed for coal from those districts. A supplementary statement will be issued within a few days covering prices on coal produced in those districts.

The action taken at this conference, brings about the following results:

Present prices on bituminous coal mined in Pennsylvania have ranged from $4.75 to $6.00. Under the ruling the price is reduced to $3.00 for mine run and $3.50 for domestic lump, egg, and nut.

The present range of prices in West Virginia is from $4.50 to $6.00; price reduced to $3.00 for mine run and $3.50 for domestic lump, egg, and nut.

The range of prices for Ohio coal has been from $4.50 to $5.00; prices reduced to: No. 8 district, the thick-vein Hocking and Cambridge districts, $3.00 for mine run and $3.50 for domestic lump, egg, and nut; thin-vein Hocking, Pomeroy, Crooksville, Coshocton, Columbiana County, Tuscarawas County, Amsterdam-Bergholz district, $3.25 for mine run and $3.50 for domestic lump, egg, and nut; the Massillon and Palmyra districts and Jackson County, $3.50 for all grades of coal.

The prevailing prices in Alabama have been from $5.50 to $5.75; prices reduced to: Cahaba and Black Creek, $4.00; Pratt, Jaeger, and Corona, $3.50; Big Seam, $3.00 for all grades.

The prevailing prices for coal mined in Maryland have been from $5.75 to $6.00; reduced prices will be $3.00 for mine run and $3.50 for domestic lump, egg, and nut.

The prevailing prices on coal mined in Virginia have been $4.50 to $5.00; reduced price, $3.00 for mine run and $3.50 for lump, egg, and nut.

The prevailing prices on coal mined in Kentucky have been from $4.00 to $4.50; reduced price, $3.00 for mine run and $3.50 for the domestic sizes.

The prevailing prices on coal mined in Illinois and Indiana have been from $3.50 to $4.00; reduced price, $2.75 for mine run and steam sizes and $3.50 for screened domestic sizes.

The prevailing prices on coal mined in Tennessee have been from $4.50 to $5.00; reduced price, $3.50 for all sizes.

This action of the Committee on Coal Production was not sanctioned by the Department of Justice and was

repudiated by the Secretary of War as Chairman of the Council of National Defense. Nevertheless, the agreement was effective in halting the rising price of coal and was literally followed by the majority of the vendors of coal until, on August 21, 1917, prices were finally fixed by the President under authority of Food and Fuel Control Act[4] of August 10, 1917, which was the organic act of the United States Fuel Administration established by executive order of August 23, 1917, with Harry A. Garfield as Fuel Administrator. One direct result of the efforts of this Committee that will outlive its other achievements was the promotion and organization of the National Coal Association, the first serious effort of the bituminous-coal operators of this country to act in concert.

The prices for bituminous coal fixed by the President on August 21, 1917, are given in the table opposite.

The most pressing questions before the Fuel Administrator, to which office Harry A. Garfield, President of Williams College, was appointed by the President on August 23, 1917, were the adjustment of wage scales for mine laborers and the adjustment and administration of prices of coal. The adjustment of the prices to be fixed at the mines required an elaborate investigation of the cost of production — an investigation which was slow and tedious, yet absolutely necessary before serious and proper effort could be made to accelerate production. The administration of prices involved the establishment of state and local organizations to determine for each

[4] "An Act To provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of food products and fuel," quoted in Appendix I. For a description of the organization and operations of the United States Fuel Administration under this Act see, in this series, W. F. Willoughby, *Government Organization in War Time and After.*

SCALE OF PRICES FOR COAL PER NET TON, F. O. B. CARS AT THE MINES, AS FIXED BY THE PRESIDENT, AUGUST 21, 1917

State	Run of Mine	Prepared Sizes	Slack or Screenings
Illinois	$1.95	$2.20	$1.70
Illinois (third vein)	2.40	2.65	2.15
Indiana	1.95	2.20	1.70
Iowa	2.70	2.95	2.45
Pennsylvania	2.00	2.25	1.75
Maryland	2.00	2.25	1.75
West Virginia	2.00	2.25	1.75
West Virginia (New River)	2.15	2.40	1.90
Virginia	2.00	2.25	1.75
Ohio (thick vein)	2.00	2.25	1.75
Ohio (thin vein)	2.35	2.60	2.10
Kentucky	1.95	2.20	1.70
Kentucky (Jellico)	2.40	2.65	2.15
Alabama (Big Seam)	1.90	2.15	1.65
Alabama (Pratt, Jaeger, and Corona)	2.15	2.40	1.90
Alabama (Cabaha and Black Creek)	2.40	2.65	2.15
Tennessee (eastern)	2.30	2.55	2.05
Tennessee (Jellico)	2.40	2.65	2.15
Arkansas	2.65	2.90	2.40
Kansas	2.55	2.80	2.30
Missouri	2.70	2.95	2.45
Oklahoma	3.05	3.30	2.80
Texas	2.65	2.90	2.40
Colorado	2.45	2.70	2.20
Montana	2.70	2.95	2.45
New Mexico	2.40	2.65	2.15
Wyoming	2.50	2.75	2.25
Utah	2.60	2.85	2.35
Washington	3.25	3.50	3.00

community — for each dealer, in fact — the price that might properly be charged the householder, for it was the domestic consumer whose need of attention was the most urgent.

Price, however, is not a cause but an effect; a reasonable price without the coal availed nothing. The real

reason for concern lay in the fact that the consumer was getting somewhat less coal than he really needed and much less than he thought he needed. If in the winter of 1917-18 the country had been willing to subordinate every other consideration to the production of coal by sidetracking all other freight, by denying the use of open-top cars to all other commodities, by hauling coal and nothing else, every need, real and imaginary, could have been satisfied. But such a course, even for a product so essential as coal, could not be taken; iron and steel for ships and war munitions and food for soldiers and citizens must also be moved without halt.

The supreme problem, therefore, was to get efficient distribution — distribution of everything that could be produced and hauled to serve best the needs of the war, which meant keeping the people warm, the public utilities in operation, the railroads and ships supplied, and the war industries going at full speed; distribution that would conserve precious means of transportation by eliminating the needless long haul and the wasteful cross-haul; distribution that would give the consumer the kind of coal he needed; distribution that would spread out the supply and build up stocks for use in winter at the more distant points.

The efforts of the Fuel Administration to solve this problem in the winter of 1917-18 were seriously hampered (1) by lack of organization and experience, for even the most cursory supervision of the distribution of 2,000,000 tons of coal a day is a large task; (2) by the inability of the railroads, until the President took control of them in January, 1918, to coöperate effectively; and (3) by the fact that the greater part of the coal produced in that period was covered by contracts at prices both far above and far below those established

by the Government, contracts which the Fuel Administration was unwilling, and perhaps unable, to cancel and which therefore had a large effect on the movement of coal.

The first and probably the most effective step taken to control the distribution of coal was the establishment on April 1, 1918, of the zoning system, by which the movement of bituminous coal was restricted to markets in territory nearest the mines. This system furnished a sure and ready means of controlling the movement of coal and effected an immense saving in transportation, a saving that on one railroad alone, as estimated by its officials, amounted to 15 per cent. The boundaries of the zones were fixed by the United States Fuel Administrator and the Director-General of Railroads, who expanded or contracted them as occasion might arise. The coals of the East were thus withheld from the West in ever increasing quantities to meet the ever increasing needs of the eastern centers of the war industries, and the coals of the Middle West were taken eastward to supply the deficiency thus produced.

The zones are best described as areas bounded by imaginary lines within each of which was a coal-producing field and a coal-consuming section of the country. The size of the zone was determined by the ability of the particular field to produce and supply the market, and the shape and location of the zone were determined by the transportation offered from the coal field. The zones were added refinements to the budget system to be described hereafter in that they added the coöperation of the railroads in determining the best use of existing transportation and in the policing of distribution by use of railroad embargoes in accordance with the budget.

Thirteen zones were originally outlined, a number of which were subsequently subdivided. As an example of the operation of the system the zone for "smokeless" coal from the Pocahontas and New River fields, known as Zone N, may be cited. It was decided that except for the manufacture of by-product coke no "smokeless" coal would be allotted to consumers west of Columbus and Cincinnati, and that the greater part of this coal must be shipped east to tidewater at Hampton Roads or to inland markets in Virginia and the Carolinas. The considerations that prompted this decision were briefly that all the coal of this grade that could possibly be taken from normal western users was needed at tidewater for the Navy, for fueling steamships and transports, for export, and for trans-shipment to New England, and, further, that the hauling of smokeless coal west was hauling it across large coal fields on the same railroads — in other words, a cross-haul.

The effect of the smokeless zone was to take from the western market something over 2,000,000 tons of this coal that had been consumed principally in Chicago for domestic use and make it available for shipment to tidewater. Coal from Illinois mines was provided to replace the eastern tonnage thus withdrawn by prohibiting the shipment of coal from Illinois to western Iowa, Nebraska, western Missouri, and Kansas. To replace the Illinois coal thus withdrawn from these normal markets the producers in the coal fields of Iowa, Missouri, and Kansas, as well as those farther west, in Colorado, Wyoming, and Montana, were called upon for increased production and shipments east. This was possible and was accomplished because the coal fields in these western states had not in 1916 or in 1917 produced to their capacity, particularly in the summer months, because of

the competition offered by Illinois coal and by coal from fields farther east. This briefly outlines one example of the purpose and accomplishment and the various problems involved in the establishment and administration of the zoning system.

Soon after his appointment the Fuel Administrator announced a plan of budgeting the coal supply for each coal-consuming state, but it was not until the spring of 1918 that this plan could be put into effect. During the winter of 1917-18 a comprehensive organization was built up, consisting of a representative of the Fuel Administration in each of the 30 coal-producing districts, with state administrators representing the consumers in each state and a central office in Washington to direct the work and to gather and analyze the statistics of production, distribution, and consumption.

The budget showed the estimated amount of coal required for each state and the source, by field or fields, of the coal, and in its preparation consideration was given to the need, for special uses, of particular grades of coal — grades that only certain fields can supply. The main object of this budget was to fix ends or goals toward which efforts of production and distribution should be directed and by which performance could be measured. Furthermore, the budget was the guide as to the division of coal between the consuming states and the major industries and uses, such as railroad fuel, ship bunkers, and domestic consumers, and it thus provided for equality in supply or in shortage, as the case might be.

In a great war all consumers do not have an equal right to fuel. Coal to keep people warm, to fuel the railroads and steamships, and to manufacture certain war necessities, it will be agreed, is of first importance.

Although no class of consumers may in itself be considered non-essential, certain classes are less essential to the national welfare than others. The function of determining the order or priority of right or need of the coal consumers lay with the War Industries Board, and the principles somewhat tardily laid down by this Board governed the Fuel Administration in the distribution of coal. It will at once be understood that the application of this principle of priority introduced a new and variable element into the distribution of coal under the budget, for the percentage of consumption by the preferred consumers varied as between states. Furthermore, in their application and use the several kinds of bituminous coal differ as widely as anthracite differs from soft coal, and coal suitable for ships and for making gas or coke can be had only from a small number of mines in certain fields.

The Priorities Division of the War Industries Board in a statement issued on September 3, 1918, described the operation of the priorities in the following language:[5]

> The President has placed upon the Chairman of the War Industries Board the responsibility for determining and administering all priorities in production and delivery. The determination of the relative importance of all industries and plants for both production and delivery by a single agency renders it possible to reasonably maintain a well balanced programme with respect to the several factors entering into production, which include (*a*) plant facilities, (*b*) fuel supply or electric energy, or both, (*c*) supply of raw materials and finished products, (*d*) labor, and (*e*) transportation by rail, water, pipe lines, or otherwise. Without all of these, speaking generally, production is impossible.

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[5] Circular No. 20, Preference List No. 2, War Industries Board, Priorities Division. For a more detailed discussion of the system of priorities see, in this series, W. F. Willoughby, *op. cit.*

In compliance with the directions of the President that plans be formulated whereby there may be "common, consistent, and concerted action" in carrying into effect all priority policies and decisions, the Chairman of the War Industries Board has created a Priorities Board, with the Priorities Commissioner of the War Industries Board as Chairman, consisting of (1) the Chairman of the War Industries Board, (2) the Priorities Commissioner, (3) a member of the Railroad Administration, (4) a member of the United States Shipping Board Emergency Fleet Corporation, (5) a member of the War Trade Board, (6) a member of the Food Administration, (7) a member of the Fuel Administration, (8) a representative of the War Department, (9) a representative of the Navy Department, (10) a member of the Allied Purchasing Commission, and (11) the Chairman of the War Labor Policies Board.

The decisions of the Priorities Board are subject to review only by the Chairman of the War Industries Board and by the President.

For the guidance of all Government agencies and all others interested in (1) the production and supply of fuel and electric energy, (2) the supply of labor, and (3) the supply of transportation service, preference lists were adopted and published by the Priorities Board, classifying, where advisable or possible, by industries, and otherwise designating by individual establishments, those entitled to preference. It was stated that the inclusion of these industries and establishments did not operate as an embargo against all others, but had the effect of deferring the requirements of all other industries and establishments until the requirements of those on the preference lists had been satisfied.

Industries and plants were divided in these lists, according to their relative importance, intó four classes, in the determination of which all of the following factors were stated to have been considered: (1) the intrinsic

importance of the product itself for use during the war, and the urgency, as measured by time, of the demand or of the use to which it is to be put; (2) the necessity for maintaining or stimulating and increasing the total quantity of production, which in turn depends largely upon the relation of the supply to the demand for essential uses; and (3) the proportion of the capacity of the industry or plant which is devoted to the production of the essential product. The industries and plants grouped under Class I, which included such items as aircraft, ammunition, chemicals, coke, domestic consumers, explosives, foods, public institutions and buildings, public utilities, railways, ships, and steel-plate mills, were only such as were of exceptional importance in connection with the prosecution of the war. Their requirements were placed ahead of those of the three remaining classes.

An army of men was engaged in producing coal during the war; the number so employed — about three-quarters of a million — fell little short of two-fifths of the American Expeditionary Force in France at the termination of hostilities. To direct and distribute the product of the work of this army at home properly and intelligently, so that its efforts might aid and not hamper the work of the army overseas; to satisfy the needs of a hundred million at home; to utilize the product of the miners in Illinois and Indiana to meet needs that the miners of West Virginia could not supply; to use the miners of Kansas, Iowa, and Missouri to provide a virtual increase in the supply of coal for transports without physically transferring the men or their product to the vessels; to reinforce in effect the depleted ranks of anthracite mine workers with bituminous mine workers

by substituting soft for hard coal — these were some of the outstanding features of the strategy of the Fuel Administration.

Prior to 1916 there were few periods in the history of this country when coal could not be had almost for the asking. Coal was cheap: the mines, men, and cars were available to supply more than the needs of the consumer, and competition between producers served to keep the average price just above the actual cost of production. Because coal was cheap, nearly all consumers have been careless and wasteful in its use. Because coal was mined more easily than it was sold, competition between fields has been active, and consumers have been taught to prefer the products of certain mines or districts. The furnaces in many factories and the stoves in many homes were installed to burn coal of particular grades, which must be hauled from far-off coal fields across adjacent or nearer fields. The farmer of Iowa demands lump coal from eastern Kentucky, which must be brought to him across the coal fields of Illinois and Indiana past the mouths of mines in his own state. Burning coal to haul coal over coal fields is obviously wasteful, and both coal and transportation were saved by the zoning system, which limited this practice.

Transportation was saved also by inspecting the coal that was loaded into cars at the mines, for hauling dirty coal is a wasteful use of valuable cars, and burning dirty coal is an unnecessary tax on industry. The operator and the laborer have been educated and encouraged to make greater effort to put forth only the best product obtainable.

More than two-thirds of the soft coal mined in this country is used in making steam in locomotives, steamships, factories, and mills. The desirability of conserving

coal by improving firing practice under the innumerable boilers that consume this coal is as great as the desirability of effecting a saving in mining and transportation. The inefficiency of the unskilled fireman in the boiler room can offset the increased efficiency of the mine worker, and so the country gains nothing. The education not only of the fireman, but of the engineer and plant manager, was therefore seriously undertaken, and although the results of the campaign to "save a shovelful of coal a day for Uncle Sam" cannot yet be accurately measured, results have evidently been accomplished — results that are cumulative and that will endure long after the war. It has been truly said that if conservation could help to win the war, it will also help to pay for the war.

The United States leads the world in the production of coal. Its leading position, attained before the war, has been made more secure during the last four years, for as the production in the other leading coal-mining countries declined with the progress of the war, the production in the United States increased. Although the peak of the consumption of coal in this country for some time reached its maximum in 1918, and although production will not soon again reach its war-time height, there is ample reason to expect an increase in the demand for American coal for export and steamship bunker fuel. The cheapness of coal in this country, measured in man power required to produce it, and the ready availability of the large and varied reserves insure a supply of fuel in sufficient abundance to encourage an industrial growth in the United States in the next generation at least as great as that in the last. The average *per capita* consumption of coal in this country, five tons, is greater than in any other country, the pre-

war records for the other industrial nations — England, Germany, and Belgium — being about four tons. The coal exported from the United States has never represented more than four to five per cent. of the total output, and most of this coal has been sent to Canada. The ships that were built during the war to fly the American flag will take our coal in increasing quantities, both for use and as cargo. Production, stimulated to meet the war-time demand, will be ready to seek an outlet for part of the product by export when the home demand slackens.

The United States holds first rank also in the production of petroleum, with an even greater lead than in its production of coal. The annual output of petroleum in the United States is about two-thirds of the world's current supply and has been for more than half a century. The products of petroleum, like those of coal, are manifold, and their use is increasing with the progress of civilization and industry. Gasoline, kerosene, fuel oil, and especially lubricating oil made from petroleum have no substitutes in industry today. Gasoline-propelled trucks have helped to supply the demands of transportation at home and behind the battle lines, and kerosene and fuel oil have made possible the construction and use of speedy boats to convoy the merchant ships and transports on the ocean. The production of petroleum in the United States has reached a new high level in each year, and the year 1918 was no exception.

The increase in the production of natural-gas gasoline in the United States from 24 million gallons in 1913 to about 175 million gallons in the first half of 1918 was one of the contributions made by this country to meet the

greatly increased demand for motor fuel, yet the shortage of that fuel became so great in the summer of 1918 as to necessitate a curtailment of the use of automobiles. The voluntary response of the people to the request to abandon pleasure riding on Sundays resulted in the accumulation of a reserve estimated at not less than a million barrels of gasoline available for war uses.

Oil was saved during the war by adopting nearly the same practice that was applied to coal — by eliminating unnecessary hauls and waste. Natural gas, a mineral fuel that is associated with oil, is lost in immense quantities through neglect or wanton waste, and efforts were made to conserve the supply. The strategy of the Fuel Administration consisted in increasing the output of both oil and gas with the least expenditure of labor and of pipe and casing, as well as of drilling equipment. To this end the supplies needed for producing oil and gas were furnished only for use in territory where the geologic and other available information promised the best chances of profitable production. Coöperation of the Fuel Administration with the Capital Issues Committee also insured the expenditure of the people's capital only where it was likely to bring returns to the investors and to benefit the public. In the handling of applications for both drilling supplies and capital the records and the personnel of the scientific bureaus of the Department of the Interior were made serviceable, and the experience gained has shown the practical value of enlisting technical advice in these efforts to put material and men where they will count for the most. The oil companies have learned that in some areas the chance of striking oil and gas by drilling based solely on geologic advice has been 50 to 60 per cent. or even more,

as contrasted with one or two per cent. by drilling done wholly at random.

The United States is the largest consumer of petroleum and its products, as well as the largest petroleum-producing country in the world. That we have more than 90 per cent of the automobiles in the world is due to the abundance of petroleum, and no small part of our material and industrial prosperity is due to the almost prodigal use we have made of this priceless natural resource. It is time to sound a warning to our people, however, for the petroleum reserves of this country are limited and at some no far distant date bid fair to fail to supply the ever increasing demand. To supply our needs, and including exports of refined products, in 1918 it was necessary to supplement the domestic production of 355,928,000 barrels with 27,000,000 barrels withdrawn from stocks, and 31,000,000 barrels of imports, chiefly from Mexico. The rate of consumption in the United States is now more than 400,000,000 barrels a year. Our reserves are estimated at 6,740,000,000 barrels,[7] or sufficient for less than 20 years at our present rate of production and consumption. Our new merchant marine of 16,000,000 tons is being built to burn oil, and as a ton of shipping requires (roughly) seven barrels of oil a year for fuel, a new and very large demand is being placed on our reserves, one that makes it imperative that the United States lend aid and support to its nationals in securing foreign reserves of petroleum; imperative if the United States is to maintain the degree of material prosperity on land resulting from the common use of petroleum products, and if the new merchant marine is to succeed in competition with that of other nations.

[7] David White: "Oil Resources of the Public Land States," U. S. Geological Survey Bulletin 711, in press.

The situation demands also prevention of waste and the more economical and efficient use of oil and gasoline. If not prevented by price, the time may come when legislation will be enacted forbidding the use of petroleum for steam-raising under boilers. Lubricants can be had only from natural oils, and power can be much more efficiently developed from internal combustion motors than from steam engines. A large source of petroleum not yet utilized in this country lies in the deposits of oil shale in the western states. The 40 billion barrels of oil locked up in the rocks of the desert hills in Colorado, Utah, and Nevada assure to the United States a supply for the more distant future that is more evident and more certain than the buried pools of petroleum, and most of the area in which it occurs is still in public ownership.

In the greater strategy of trade and of economic world relations and in the problems that may hereafter be considered by the League of Nations the United States will be independent of all other nations in its coal supply and will have an exportable surplus of this fuel, but needs to turn to foreign lands for a part of its petroleum. Lord Curzon's statement that the "Allied fleets floated to victory on a sea of oil" is a striking estimate of how essential America's contribution of 80 per cent. of the naval requirements was in those years of stress. Equally true is it that the full success of our new peace fleet will depend on oil for fuel.

CHAPTER IV

TENDENCIES OF POWER PRODUCTION

William B. Heroy[1]

Human progress in the utilization of natural sources of energy — Rivalry between water and fuel power — Electric transmission as the unifier of power sources — Strategic advantages of each source — Present distribution of energy production in the United States as between fuel and water — Dependence of maritime commerce on fuel — Dependence of certain industries on fuel — Necessity for water-power production to release fuels for commerce and industrial use — Future tendencies in the utilization of power resources.

One of the standards by which the advance made by man in his conquest of the earth may be measured is his ability to use the forces of nature to perform his work. Primitive man, whether of prehistoric time or of the remote wilds of the present day, uses no strength but his own. The articles he makes are simple, and he himself supplies the energy required for their production. Civilized man has learned the secret of making Nature work for him. Mechanical and electrical energy are not only important components of many of his products, but are more and more utilized to supply his increasingly complex needs as he advances in civilization.

The first auxiliary to human strength was doubtless the strength of animals, for the period of the domestication of animals reaches back of the beginnings of history. The power of the wind was used for moving boats in very early times. The irrigators along the Nile and the Euphrates are credited with the invention of water wheels, which they used for lifting water to their fields.

[1] United States Geological Survey.

A mill driven by water was erected on the Tiber near Rome in the time of Augustus. Thus man employed natural power thousands of years ago, and at the beginning of the Christian era he had learned to utilize two of the great natural sources of energy, the wind and flowing water.

To the application of natural energy to human needs the Middle Ages contributed only the windmill, and it was not until the eighteenth century that there was a great increase in the employment of mechanical power, the result of the utilization of the expansive force of steam. This application of steam made it possible for man to use fuel as a third great natural source of energy. Appropriately enough, the first steam engines, operated by coal, were used to remove water from English coal mines, work which had previously been performed principally by water wheels.

The year 1800 marks approximately the beginning of the great industrial revolution that followed the introduction of the steam engine and its gradual adaptation to many uses. An early effect of the adoption of the new motive power was the disuse of many water wheels; in England hundreds of mills that had been run by water power were abandoned. The convenience of developing power at the place of most desirable use gave the steam engine a great advantage over the water wheel, which had to be set up at a place where there was a water power. Thus began an economic rivalry between these two major sources of energy which continues to the present day.

Through the nineteenth century much progress was made in the design and construction of engines moved by steam. The greatest single advance was perhaps the application of the principle of the turbine, resulting in

the modern turbo-generator. In 1918 a machine of this type which is to have a capacity of 60,000 kilowatts was being constructed, and a number having capacities of 30,000 kilowatts or more were in operation.

During the last generation the invention and development of the internal-combustion engine has made possible the use of liquid fuels as a direct source of power and has led to the most striking changes in business and social life. The motor car, the motor boat, and the airplane have been not only the means of gratifying personal desire for pleasure, but are increasingly utilitarian in their application. The automobile especially has now supplanted animals to a large extent, not only for pleasure but in commercial transportation and in agriculture. Nevertheless, the internal-combustion engine has not produced any changes in the use of power so fundamental as those caused by the invention and use of the steam engine, and so far as can be foreseen, it is not likely to attain so dominant a position as a means of public service.

It is the application of electric current to the transmission of power, however, that has brought about the profound changes in transportation and industry. Electric transmission has made possible two notable advances in industrial economy — the utilization of power far from the place at which it is produced, and the joint use of water power and fuel power, even where the water-power plant is hundreds of miles from the steam-power plant. The century-long contest between water and steam has thus in large measure been terminated by the formation of a coalition in which each source of power complements the other and contributes elements of strength to offset elements of weakness. An understanding of the interrelation of these two sources of

energy is essential to any intelligent plan for the future power supply of the country.

The paramount advantage of water power is that its sources are not exhausted by use — it depends mainly on solar heat and gravitation. The heat energy constantly received from the sun lifts water from the earth s surface and makes it available for precipitation and for subsequent flow in streams. Although this process is as a whole continuous, there are seasonal and cyclic variations in the quantity of moisture that may fall on a given drainage basin and consequent variations in the flow of the stream that drains it. Differences in climate and in geology, topography, and vegetal cover cause great differences not only in the total quantity of water that flows in streams in different regions, but in the rate of flow from time to time. The streams in a region where the rainfall is large naturally have large run-off, whereas most of those in an arid region flow only after an occasional cloudburst or with the melting of snow. Each stream thus has characteristics of flow which result from many and complex features of climate, topography, soil, and vegetation, and which give it an individuality that makes the problem of its proper utilization one that can be solved only by special study. The flow of some streams responds quickly to precipitation, and the changes in their rate of discharge are correspondingly rapid. Alleghany River, for example, is subject to rapid fluctuations, and when it is at high stages or in flood, it may cause great damage. The discharge of the Alleghany at its mouth ranges from 950 to 30,000 cubic feet per second — a variation which may be illustrated in another way by stating that in the record flood of March 15, 1907, the river at Pittsburgh rose 35 feet in five days. A rainfall of 10 inches or more in the Ohio

River basin in March, 1913, caused in five days the flood commonly known as the Dayton flood. Other streams are more constant in flow. A good example of such a stream is Niagara River, the flow of which is steadied by its immense natural regulating reservoirs, the Great Lakes. Another is the spring-fed Deschutes River of Oregon, a wonderful but scarcely utilized power stream, which within one year had a minimum flow of 4,900 second-feet and a maximum of only 11,700 second-feet.

One of the difficulties in utilizing water power is that the stream flow does not vary proportionately or coincidently with the demand for power. The stream utilized may be high at one season and low at another, but the demand for power may be essentially constant, so that the engineer must endeavor to control or regulate the flow of the stream by holding back the water at high stages and releasing it when the natural flow is small. He must accomplish this by constructing dams behind which the surplus flood waters are impounded in storage reservoirs. Dams that will form reservoirs large enough to afford complete regulation of the run-off of a stream or a drainage basin are likely to be enormously expensive, and even partial regulation may be costly. The United States Reclamation Service has expended nearly $5,000,000 in constructing the Arrowrock Dam, on Boise River in Idaho, yet even this great structure will not completely regulate the flow of the stream. The Pittsburgh Flood Commission has estimated that reservoirs which will only partly abate the floods at Pittsburgh will cost nearly $22,000,000.

The immense estimated cost of the work required has prevented the complete control of many drainage areas for the development of power. Partial regulation that

will increase the minimum flow during the low-water period is common, however, and on most rivers that are to be used for generating power, such regulation is practically essential. In some favored localities it has been possible to construct without great expense reservoirs of sufficient capacity to store water during a year when the flow is greater than normal and hold it for use in a year when the flow is less than normal. If storage is essential to a water-power project, it represents an additional item of cost, perhaps large, and increases the discrepancy in the first cost of plant between water power and fuel power.

Most water-power plants must supply energy to consumers who, by starting or stopping motors, may at any moment greatly increase or diminish the load on the plant. The demand on public utilities that supply power to towns and cities is relatively small between midnight and dawn, but is increased early in the morning by the movement of street cars which carry workers to mills and offices and later by the operation of machinery in shops and factories. The demand is likely to drop at noon and to be resumed in full after the lunch hour. When the days are short, the peak of the load will probably be reached early in the evening, for it is then necessary to use lights on the streets and in buildings before the factories have stopped for the day. An experienced engineer who was asked when the peak load for the year came on his system replied: "Five o'clock in the evening of the day before Christmas."

To meet these variations in demand a water-power plant must be so designed that water may be stored at or near it during the off-peak periods and used to generate the heavy loads of power required during the day and early in the evening. For this purpose a fore-

bay having a capacity sufficient to increase and regulate the flow is usually constructed above the plant. Where it is not practicable to construct a forebay, a fuel-power plant must be used as an auxiliary source of power when the demand exceeds the supply available from stream flow.

Thus a water-power plant can seldom, if ever, utilize fully all the water that comes to it. Water may be wasted at one time because there is no demand for the power that it might produce, and at another time because the flow is in excess of the capacity of the plant and complete regulation by storage is not feasible.

For several reasons the initial outlay of capital required to construct a water-power plant is generally greater than that required to install a steam plant of equal capacity. Sites favorable for the construction of water-power plants are found at places along streams where there is sufficient concentration of fall and of volume of flow. Hence, lands that lie adjacent to suitable power streams and that are utilized in the development of the power are valuable, and compensation for their use is one of the items of the cost of the plant. The expense of a dam may be greatly increased by the flooding of large areas of valuable land. Most water-power plants require much larger areas of land than equivalent steam-power plants.

The structures required for the utilization of water power are necessarily massive and consume large quantities of material. In constructing a dam it may be necessary to divert a river from its channel, and this work and unforeseen obstacles met in providing suitable foundations may increase the cost of the plant beyond the estimates. Besides, there is always danger of damage from floods that may occur during construction.

As the turbines and the electric generators required for hydroelectric plants are speeded slower than those used in steam-power plants of the same capacity, they are usually heavier and are consequently more expensive. The first cost of a hydroelectric station may therefore be two or three times as great as that of a steam station of the same rating.

This large initial expenditure is justified only because a water-power plant can generally be maintained and operated more economically than a steam-power plant. The saving in man power over steam is very large, especially if the number of miners required to provide coal is considered. The Alabama Power Company has forcefully illustrated this by showing that its plant at Lock No. 12 on the Coosa River, which has a capacity of 75,000 kilowatts, is operated by only 12 men, a return of 6,250 kilowatts per man. Its Warrior steam plant, which has a capacity of 20,000 kilowatts, requires 40 men for operation, and the production of the coal at the adjoining mine requires 230 men, altogether one man for each 74 kilowatts.

Fully 80 per cent. of the power generated in the United States for manufacturing and for operating public utilities is obtained from fuel. This great preponderance of steam over water power indicates that it possesses certain great advantages. To illustrate these advantages let us consider for a moment the position of the promoter of a power plant in a small city that is not near any water-power site or any transmission system supplied by water power. His first consideration would be the cost, as he would have to raise the money for the plant, and the smaller the sum required, the more easily he could obtain it from the bank or through the sale of securities. The lower cost of the steam-power plant

would thus be in its favor. He would want to build quickly, so that he would begin to receive a return on his invested capital as soon as possible, and therefore he would be attracted by the shorter time required for constructing the steam-power plant and the consequent smaller outlay for interest during construction. He would expect to make the initial installation large enough to carry the load imposed, and yet would prefer to design the plant so that it might easily be enlarged to meet future demand. His engineer would show him that a steam-power plant could be more easily enlarged than a water-power plant. If he were a manufacturer, he might see advantages in maintaining a steam-power station as an integral part of his factory, for he might be able to use the exhaust steam for heating or for industrial processes. He might find that he could use direct mechanical drive to better advantage than electric motors and thus avoid the expense of installing motors. All these and many other things might convince him that steam power, even if it is more expensive to produce, would be better adapted to his requirements, especially as he could probably sell his power at a rate high enough to cover operating expenses and still yield a satisfactory return on his investment. All these reasons have doubtless had their influence in establishing steam power in its predominant position.

Perhaps the chief reason for the predominance of steam power, however, is the fact that water power is not everywhere available. Always capricious, Nature has been no more impartial in her distribution of this resource than in that of many others. Some of the greatest industrial and commercial centers of the country have practically no water power. New York, Philadelphia, Cleveland, Cincinnati, Detroit, Washington,

New Orleans, and Galveston have none. Boston and Chicago have relatively little. Even Buffalo, with Niagara at its gates, is now largely dependent upon steam. Many small industrial cities in the East and Middle West have no water power near by and are not within practicable reach of a hydroelectric plant. Nine states are each credited with less than 5,000 horse power of developed water power.

Water power has unquestionably played an influential part in the location of many industries and the establishment of many centers of population. Many a city owes its existence to a water power around which its early industries centered. "The small industrial towns of colonial and early Commonwealth times have grown to be the important manufacturing and commercial centers of today. Lawrence, Lowell, Holyoke, and scores of smaller cities still depend on water power as the principal source of energy, although steam plants have been constructed to supplement the power obtained from the rivers."[2] The "fall line" cities of the South are monuments which mark the zone in which the great rivers of the Atlantic slope pass over falls or rapids from the hard rocks of the Piedmont region into the softer sediments of the Coastal Plain.

But other communities have had cheap fuels and other weighty natural advantages that have made up for the lack of cheap water power. Pittsburgh, the center of the district that leads the United States in the consumption of bituminous coal, obtains no power from water but derives the means of most of its industrial activity and progress from nearby coal fields. The industrial prosperity of St. Louis must be attributed in

[2] N. C. Grover, "Surface Waters of Massachusetts," U. S. Geological Survey Water Supply Paper 415 (1916), p. 4.

large part to the transportation facilities afforded by the great navigable river on which the city stands and to the coal of Illinois and Kentucky, which has been near at hand, plentiful, and cheap, for it is only within a decade that water power has been brought to St. Louis from the Keokuk dam.

No two water-power sites are exactly similar in physical character, and the development of each site is therefore a special problem in design and construction. Even two adjacent sites on the same stream may require structures of widely different type. These differences cause great variation in the quantities of materials and labor required to build a plant; indeed, they so fully control the cost of construction that it is almost impossible to estimate closely the average cost of producing power from water. Because of these differences one water-power plant may be cheap or expensive to build and operate as compared with another water-power plant or with a plant operated with fuel. Unquestionably the cheapest power now available in this country is obtained from some hydroelectric plants which, on account of peculiarly favorable conditions, have been constructed and are operated at a low cost, yet even other water powers that have cost more are successfully competing with steam. Many water powers, however, cannot now be economically developed because they cannot furnish power as cheaply as it can be produced from fuel, and the general principle may be stated that water power can be developed successfully only where the cost of the product is no greater than that which can be obtained from fuel. The site that affords the cheapest power below that limit will normally be developed first if the markets to be served are equally favorable. The development of water powers in a given region therefore, may

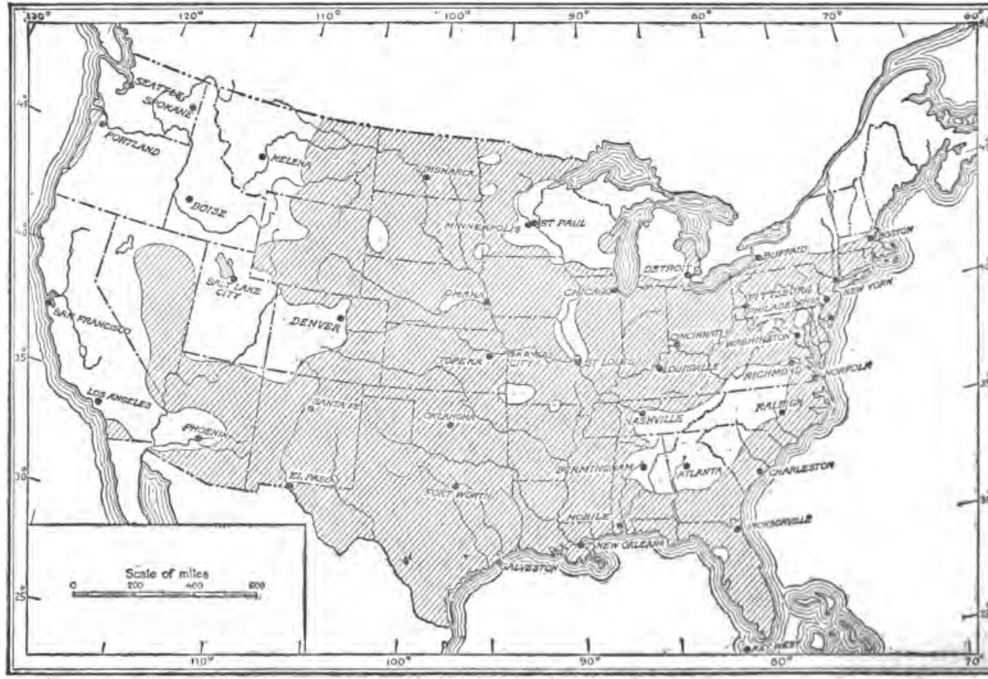

FIGURE 1. SOURCES OF POWER IN THE UNITED STATES. SHADED AREAS ARE THOSE IN WHICH THE GREATER PART OF THE POWER IS DERIVED FROM FUELS; UNSHADED AREAS ARE THOSE IN WHICH THE GREATER PART OF THE POWER IS DERIVED FROM WATER

pause after the more favorable sites have been harnessed. The most costly sites may have to wait until the rising cost of fuel power makes their development possible, so that many sites of great potential value will long remain unutilized.

The control exercised by these conditions and the amount of power required in the market will determine at any given period the areas that must be supplied from water power and those that must be supplied from fuel power. The areas in the United States in which each source of power is now dominant are shown on the accompanying map (Figure 1). Such a map must necessarily be diagrammatic in some parts for in many areas the intermingling of fuel power and water power is complex. Areas that are supplied principally with fuel power when the streams are low may be fully supplied with water power when the streams are high and hydroelectric plants can operate at their full capacity. This condition prevails in a large part of New England, where much steam power is used as an auxiliary to water power. At some places water power may be used only to supply certain needs of the community, and power generated from fuel may be used to supply the rest of the needs. The water power on the James River at Richmond, Virginia, supplies a part of the requirements of the city, including those of the municipal lighting system, but a large amount of the additional power needed is generated by steam. Chicago obtains power from the water-power plant at Lockport, but the power supplied by this plant is small in comparison with that supplied by the great steam stations of the Commonwealth Edison Company. In California, which is now a vast network of transmission lines and is shown on the map as part of a water-power region, one-third of the power used is ob-

Capacity of Electrical Generators Installed in the United States on December 31, 1917

(Includes commercial and municipal central stations, electric railway stations, and manufacturing plants that furnish power for public service. Does not in general include generators installed in private electric plants.)

STATE	KILOWATTS	STATE	KILOWATTS
Alabama	157,173	Nebraska	90,386
Arizona	48,652	Nevada	10,580
Arkansas	30,489	New Hampshire	47,238
California	862,879	New Jersey	293,789
Colorado	131,617	New Mexico	20,493
Connecticut	235,030	New York	1,722,201
Delaware	20,717	North Carolina	171,127
District of Columbia	63,250	North Dakota	20,625
Florida	57,488	Ohio	780,174
Georgia	214,814	Oklahoma	70,381
Idaho	115,109	Oregon	109,593
Illinois	799,474	Pennsylvania	1,072,376
Indiana	336,668	Rhode Island	155,275
Iowa	284,224	South Carolina	163,223
Kansas	153,725	South Dakota	26,687
Kentucky	105,933	Tennessee	166,572
Louisiana	62,292	Texas	174,898
Maine	93,605	Utah	77,466
Maryland	130,429	Vermont	82,684
Massachusetts	776,702	Virginia	160,803
Michigan	546,298	Washington	268,358
Minnesota	275,631	West Virginia	148,594
Mississippi	33,507	Wisconsin	326,585
Missouri	267,368	Wyoming	22,435
Montana	186,271	Total	12,171,888

tained from fuel. A reference to such complexities must therefore serve as a warning to the reader against too literal an acceptance of the boundaries shown on the map, yet they give a good general idea of the distribution of the power derived from these two sources.

The map shows only the predominance of the use of one or the other kind of power; it does not show the relative concentration of the use or development of power in the areas represented. This concentration is exhibited, by states, in the accompanying table, which shows the capacity of the electric generating equipment installed

in each state on December 31, 1917. The table represents roughly also the distribution of the energy among the states, though a great deal of power is transmitted across state lines. Nevada, for instance, receives electric power from plants in California, and the capacity of the plants in Nevada as indicated in the table is therefore not a fair index of the amount of electric power used in the state. Similarly New York receives from the Canadian side at Niagara Falls power equivalent to about 100,000 kilowatts.

The limitations imposed as indicated on the production and distribution of electric energy generated by water power make a large proportion of this power unavailable as a substitute for fuel. The transportation of freight of all kinds especially is now largely dependent upon fuel, as by far the greater part of the country's freight is moved by locomotives and vessels that burn coal or oil. Electric railways are devoted primarily to passenger traffic. The mileage of steam railroad that has been electrified is still relatively small; the only example of the large use of water power on such a railroad is seen in the electrified part of the Chicago, Milwaukee & St. Paul Railway, where 440 miles of line is operated with electric locomotives. The magnitude of the demand for fuel for our steam railroads is seen in the fact that they used 28 per cent. of the bituminous coal and 14 per cent. of the oil produced in the United States in 1917.

The demand for coal and oil for use by vessels is rapidly increasing. In 1917 vessels engaged in the foreign trade consumed 7,700,000 tons of American coal, and vessels plying on the Great Lakes and in the coastwise trade consumed perhaps 5,000,000 tons. About 5,000,000 barrels of petroleum was consumed by vessels engaged in overseas shipping, and a large additional but un-

known amount was consumed by vessels engaged in the coastwise trade. The consumption of fuels in the foreign trade and by the Navy greatly increased during the war, and not a little fuel was lost to commerce through the operation of the enemy's submarines. Since our shipbuilders are now able to increase our merchant fleet with rapidity, the foreign trade will demand a larger and larger share of our fuel.

The dependence of the steel industry upon coke is discussed in another chapter.[8] It is sufficient here to state that 10 per cent. of the bituminous coal produced in 1917 was used for making coke, most of which was used in the manufacture of iron and steel. As steel is essential to our industrial life, the quantity of coke used for making it will no doubt continue to increase materially. Many other industries are similarly dependent upon coal, either for the heat obtained by its combustion or for its chemical action as an oxidizing agent. New chemical and metallurgical processes may make other sources of energy available for these uses, but the assumption that such processes may diminish our consumption of fuel in the near future rests on no secure foundation. The electric furnace may perhaps be so greatly improved as to make possible the economical use of energy derived from water power in many processes that heretofore have required fuels.

It therefore seems clear that for the present and perhaps for many years to come the Nation's fuel budget must contain large allotments for steam railroads, for shipping, and for the metallurgical and chemical industries. The development of additional water power will help land transportation and industry but will not assist the movement of vessels. Cheap fuel is essential to vigor-

[8] Chapter V.

ous maritime power, and it must be available not only at our own ports, but at coaling stations to which it must be carried from our ports. Our vessels engaged in trade with Africa and South America will have to be supplied with our bunker coal and oil, and not only shall we have to think of our own vessels, but as Nature has richly endowed us with coal and oil, we shall have to share these resources with less favored countries with which we are on friendly relations and which may wish to send ships to our harbors.

A well considered national policy must recognize the necessity of using fuel for performing work that cannot be performed with other sources of energy. Our fuel reserves are large, but they are by no means inexhaustible, and after the deposits that are more readily available are exploited, the cost of producing mineral fuels will necessarily increase. The deeper coal beds and oil sands are, of course, more expensive to exploit than the deposits that lie nearer the surface. Over a million men are now employed in producing mineral fuels in the United States, and, on account of the competitive demands of other industries, it is unlikely that more will be available for this work after the war. This relative reduction in available man power may decrease our production of coal and cause a shortage of energy that will seriously curtail our industrial output. The country must, therefore, endeavor to maintain its supply of energy by further developing and improving the methods of generating and using hydroelectric power and by increasing the efficiency with which fuel is converted into energy.

Even in areas where the additional water power that can be developed is limited by economic and geographic considerations, the power now available can be more

completely utilized. Some well known water powers in the East are now used so inefficiently that they yield less than half the energy that the water can supply. Plants of antiquated design and machinery of obsolete type, maintained by a conservatism that is loath to replace old by new devices, such as mechanical by electrical equipment, are the principal causes of this low efficiency. Even at Niagara only about two-thirds of the power afforded by the total fall between the lakes is utilized by the plants now in operation. One of the largest water powers in New England, Bellows Falls, on the Connecticut River, is now utilized only to about one-fourth of its potential capacity.

Some water powers that have been developed by modern plants are not fully utilized because the plants are not connected with distribution systems large enough to use all the power that the water can produce. These plants must establish other connections in order to make possible their maximum production. Thereafter the interconnected steam-power plants would operate only as auxiliaries to assist the water-power plants on peak loads and in periods of low water. Such deficiencies and inefficiencies can be discovered only by means of a careful power survey of the country that will show the location and the relations of existing power plants and the possibility of improving their interconnections. The war found the country without comprehensive information of this kind, and the United States Geological Survey, in coöperation with the Fuel Administration and the War Industries Board, therefore collected the information required to prepare maps showing the location of power stations and transmission lines. These maps and the information collected have revealed many opportunities for interconnection that before were but vaguely

realized. The Survey plans to continue the study of such problems during the period of reconstruction, when the country, with reduced man power, must still further replace the laborer by the electric motor or raise him to the rank of a skilled workman armed with a pneumatic tool.

There is a growing tendency to redistribute the industries of the country so that those which require large amounts of power may be located in areas where water power is abundant and cheap, and the availability of an adequate supply of power may thus soon control the location of many industries, especially those in which the cost of power is a large item in the value of the product. The West, with its great water-power reserves, should therefore be able to attract and hold many industries that have heretofore been located in the East.

If this reasoning is sound when it is applied to power problems that arise within the boundaries of the country, it should be sound when it is applied to international power problems. Countries that have little fuel and that are well provided with water power should be encouraged to develop their water power rather than to rely on imported fuel to establish or maintain their industries, for the transportation of fuels to points remote from their source, although not always avoidable, is inherently wasteful.

To what extent may we expect water power to meet the country's future requirements of energy? The theoretical maximum quantity of hydroelectric power that can be produced in the United States has recently been estimated by Dr. Steinmetz,[4] who calculates that if every

[4] C. P. Steinmetz, "America's Energy Supply," *Proceedings of the American Institute of Electrical Engineers*, xxxvii, No. 6 (June, 1918), p. 591.

stream could be fully utilized throughout its length at all seasons, the power obtained would be 230,000,000 kilowatts (320,000,000 horse power). It is clear that only a fraction of this absolute maximum can ever be made available. The United States Geological Survey estimates that the water power in this country that is available for ultimate development amounts to 54,000,000 continuous horse power. The census of 1912 showed that the country's developed water power was 4,870,000 horse power, about nine per cent. of the maximum power available for economic development and less than two per cent. of the total that may be supplied by the streams as estimated by Dr. Steinmetz. According to the census, stationary prime movers representing a capacity of more than 30,000,000 horse power, furnished by water, steam, and gas, were in operation in the United States in 1912. This amount does not, of course, include power generated by locomotives, marine engines, automobiles, and similar mobile apparatus. The average power furnished by these stationary prime movers was probably not more than 20 per cent. of their installed capacity, so that the power produced in 1912 was equivalent to probably not more than 6,000,000 continuous horse power.

As the estimated available water power given above represents continuous power, the country evidently possesses much more water power than it now requires, so that there would be an ample surplus for many years if the power were so distributed geographically that it could be economically supplied to the industries that need it. But as a matter of fact the water-power resources of the country are by no means evenly distributed. Over 70 per cent. of the available water power is west of the Mississippi, whereas over 70 per cent. of the total horse power now installed in prime movers is

east of the Missisippi. Many large industrial areas now use no water power and would obtain little or none even under the most thorough development. Electric power is now transmitted only a few hundred miles, and there is no present prospect that it can be economically transmitted much farther. Consequently large areas in the eastern part of the United States will continue to use fuels as their chief source of power. Indeed, there will probably never be any great modification in the distribution of water power and fuel power in that part of the country. The white areas of the map may be extended slightly along the Appalachians; they may encroach upon the shaded areas in Nevada and Arizona, and their boundaries may be modified in the Rocky Mountain states from Montana to New Mexico. But sweeping changes, though by no means impossible, must be regarded as improbable. Nevertheless, national effort should be exerted to make the map whiter — that is, to increase the production of water power and to enlarge the area that is dependent chiefly upon that source of energy.

Fortunately, many areas that lack water power are near coal fields and can therefore be economically supplied with energy by erecting power plants at the coal mines. Perhaps such a plant might ' built in a natural gas field, from which transmission lines might be carried to the neighboring centers of population. During the last year one or two power plants have been built at coal mines and a contract has been made for another. The need for such plants has been emphasized by the war-time congestion of rail transportation, which several times jeopardized the supply of fuel for large central stations that obtained it by rail. The transmission of electric energy over lines of large capacity relieves the

railroads of the necessity of hauling large quantities of fuel and thus provides an important auxiliary to our systems of transportation. More than 35 per cent. of the freight carried by rail in this country is coal. In 1916 the railroads of the United States consumed nearly 143,000,000 tons of coal, about 26 per cent. of which, or 37,000,000 tons, was used in transporting coal. The average haul per ton was about 150 miles. The total quantity of coal carried by these railroads in 1916 was about 414,000,000 tons, so that they had to consume nearly a ton of coal for every 10 tons they carried. The line losses in electric transmission are at least five per cent. and may average 10 per cent. for distances of 150 miles. The expenditure of energy in electric transmission, therefore, may under some conditions be less than that involved in hauling the equivalent fuel by rail, but as the capital invested per mile of line, the cost of maintenance, and the man power required are all materially less with electric transmission, its wider use should effect a distinct economic gain.

It may thus become good national economics to construct great trunk transmission lines to convey energy from centers of water power and fuel supply to centers of industry. The New York State Conservation Commission has suggested that such a line might reach from Niagara Falls eastward to Albany and down the Hudson to New York City. A plan to construct a network of high-voltage lines that would connect the anthracite fields of eastern Pennsylvania with Philadelphia and New York has been seriously considered by a group of eminent engineers. Boston has hoped that the immense power resources of the Kennebec River, in Maine, might be brought to her gates on aluminum cables. The progress in this field of human endeavor is very rapid,

and within a few years these and similar projects may be transferred from paper to the ground. But such projects for water-power development are very costly, and they are commercially feasible only if they can furnish cheaper power.

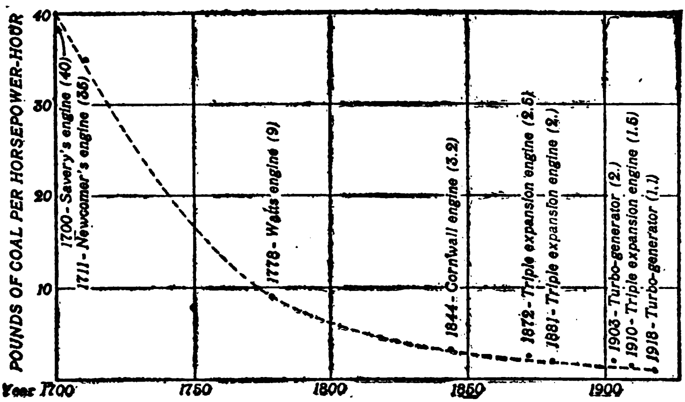

FIGURE 2. ADVANCE IN THERMAL EFFICIENCY OF PRIME MOVERS, 1700-1918

However much we may draw on water power and however greatly we may improve transportation and distribution, there will still remain a large opportunity for the better utilization of fuel — for recovering from it a larger part of its inherent energy. Even the best engineering practice of to-day makes available as electric energy only a little more than 20 per cent. of the heat of coal and perhaps 25 per cent. of the energy of natural gas, so that fully three-fourths of the energy of these fuels is unrecovered. Yet this efficiency, which we call "high" as compared with that obtained in past practice, has been gained only after two hundred years of experience and progress.

The advance in efficiency is shown in the accompanying diagram (Figure 2), in which the descent of the curve represents the increase in the economy in the use of fuel. The form of this curve is defined by points indicating the performance of engines, each of which represented the maximum efficiency attained in steam engineering at the period of its ascendancy; but it must be remembered that at any one time only a very few machines were capable of the performance indicated. Only a small part of the total fuel consumed at any such period, therefore, was used with the efficiency at tained by these engines, which are really examples of advanced practice. The engines used at any period have been of all grades of efficiency; they have ranged from those that represented maximum efficiency to those that were extravagantly wasteful of fuel. The position of the line that would represent the average efficiency in the past can only be surmised; the data available do such period, therefore, was used with the efficiency attained even to-day, much less that attained in previous times. Such a line, however, would doubtless be drawn far above the curve of maximum efficiency shown. The present average is certainly not below four pounds per horse-power-hour and may be as high as eight pounds.

The engineers who are seeking by further perfection of design to produce new units that will lower still further the quantity of fuel consumed per unit of power produced deserve the warmest encouragement, but a greater task by far is that of bringing the average power production nearer to the mark already set by the best performance of today. For this work we must rely, not on a few skillful designers, but on the men who are in charge of existing power plants. It is their economic duty to

take the plants as they find them and so operate them as to get the largest amount of power that the installations will afford. Not many power stations are capable of attaining the economy in fuel that is achieved at a modern turbine station. The abandonment or replacement of most of the less efficient plants would be an economic waste, and some useful though obsolescent stations will therefore always be with us. The skillful operation of such stations, which make up by far the larger class of power plants, offers the most promising means of the conservation of fuel.

It is perhaps opportune at this point to mention the fact that engineers are divided into two schools with regard to the location and purpose of steam-power plants. One school advocates the development of the large central plant as a source of electric energy for a large territory and urges the elimination of the small plant, public or private. The other school points to the necessity of using large quantities of fuel for heating buildings in cities and for carrying on industrial processes and emphasizes the advantages that may be obtained by combining the production of heat with the generation of electricity in the so-called "block plant." An advantage may unquestionably be obtained by so balancing a steam-heating load and a power load on the same plant that the steam may be used at high pressure for power and at low pressure, as exhaust steam, for heating. In the ordinary block plant, however, such as is found in a hotel or an office building and in most small isolated plants, the production of power is not the chief purpose of the owner or operator of the plant. He is not an expert in producing power, and as his plant is small, he is unlikely to procure and train the skilled labor that is required to get the most out of a modern equipment.

His principal source of profit is not power but heat; he may give the plant but little attention and may have no accurate knowledge of the cost of his power. Contrast with him the manager of a central station whose sole purpose is to produce power cheaply and efficiently. The advantages attributed to the central-station plan may be due as much to the manner in which the business is organized and conducted as to any inherent advantage that a station of this type may have over the block plant, and unprejudiced study of the problem may show that with equal operating skill one type of plant will give the best results under some conditions and the other type the best results under other conditions.

However much stress may be laid on economy in the use of fuel, the effort to diminish the consumption of fuel will not be due to an altruistic desire to conserve natural resources but to the necessity of keeping operating expenses as low as possible. The same incentive that will urge the operators of power plants to get more power with less coal will also prove an incentive to conduct the business with less men. The introduction of mechanical devices for handling coal and ashes has proceeded rapidly during the last decade and has made possible a reduction in the number of laborers needed in the boiler room. Scarcity of labor and high wages may therefore prove to be the practical considerations that will lead to a rapid change in the ratio of man power to output in the business of power production.

To all the questions that have here been touched upon, the war, with its attendant scarcity of fuel and labor, has given pointed emphasis. Since the outbreak of the war, as never before, the country has been compelled to consider seriously the problems of its supply of energy. But the war has merely accelerated tendencies and move-

ments which, in any event, we should have been compelled to recognize in the course of a few decades; and although the war has brought us an overwhelming train of evils, it may also bring us a large element of good if it shall awaken in us a perception of our true industrial position and shall force us to take vigorous action to develop and to use with the highest possible efficiency our unparalleled natural resources.

CHAPTER V

IRON AND ITS ASSOCIATES

A. C. SPENCER[1]

Diversity of properties and uses — Smelting methods — Steel-making processes — Alloy steels — Functions of alloy metals — Raw materials of the iron industry — Comparative pig-iron production and consumption — Comparative iron and coal reserves — Iron industry of the United States — Its organization and efficiency — Production and prices during the war period — Germany's designs on the iron resources of France — Importance of the minette ores of Lorraine — Comparative situation of Germany and the Allies — Probable result of German victory — The result under the treaty of peace — The coal problem of France — Future relations of France and Germany.

"Iron is war gold." Thus in the spring of 1918 a prominent German industrialist pointed the conclusion that Germany should not fail to possess herself of the iron-ore fields of eastern France. Because gold typifies the ultimate of desirability, the simile has all of the force intended, though it does not bear close analysis because essential utilities of gold are few, whereas the services of iron, for which there are no substitutes, are well-nigh numberless.

The great versatility of iron is obvious from our everyday knowledge of its use where widely different properties are required. Note some of the contrasts in the specifications of materials suitable for track rails and high-speed cutting tools, for crude sash weights and delicate escapement springs, for castings of intricate design, and for metal that may be readily wrought at

[1] United States Geological Survey.

the forge. Yet these and literally a thousand and one different needs are met by the iron maker through the selecting of ores; through differences in the details of smelting, of refining, and of subsequent heat treatment; and last, though not least, by alloying iron with other metals. Iron that is essentially pure is as soft and as ductile as silver. Heated to a bright red color, it may be readily welded, but it cannot be cast because it becomes merely pasty at temperatures which readily melt iron containing even less than one per cent. of other substances.

By heating a lump of iron ore with charcoal in the blast of a blacksmith's forge the ore may be reduced to a spongy mass of iron. This operation is closely parallel with the most ancient methods of smelting, which are still followed by native peoples in parts of Asia and Africa in making soft iron from small lots of ore. One of the simplest forms of furnace is a cup-like hearth arranged so as to be blown by a bellows, and though the contrast is great, it is certain that the modern iron smelting furnace has come by a direct line of evolution from this modest device.

Today the iron blast furnace, which is known in Europe under the more distinctive name of "high furnace," is an upright hollow shaft, commonly 90 feet or more in height and about 22 feet in diameter at the widest part of its bellied chamber. An up-to-date furnace is truly a voracious monster, requiring 800 tons or more of ore, about 160 tons of limestone, and 400 tons of coke each day, the balanced ration being fed mechanically at the top of the shaft while near the bottom artificial respiration is induced by huge blowers delivering per hour more than 70 tons of heated air. The outcome is roughly 240 tons of molten slag, 2,400 tons of

dust-laden gases, and 400 tons of crude iron. Commonly the slag is wasted, though it is finding an increasing use in the manufacture of Portland cement and in the place of gravel for making concrete. The gases leaving the furnace are not completely oxidized and are therefore available as fuel, for preheating the air for the furnace, and for use in the power plant. As an outcome of war, both in England and in the United States, attention has been directed to the presence of considerable amounts of potash in the dust carried by the furance gases, and as the gases cannot be used in internal-combustion engines unless they are freed from dust, by modifying the cleaning systems now employed it would seem to be entirely feasible to obtain potash as a profitable by-product of iron smelting.[2] Another suggestion that has been made is that as some of the nitrogen that enters the furnace with the blast combines with potassium derived from the charge, it may be practicable to tap off and save the nitrogen-bearing compounds, and thus to utilize the blast furnace incidentally for the fixation of atmospheric nitrogen, which is one of the most important industrial problems before the chemical engineer today. In Europe large quantities of phosphatic fertilizer are recovered in the form of slag from steel furnaces. In addition to these iron-furnace by-products those obtained in coke manufacture, which are discussed in a subsequent chapter,[3] may be credited mainly to the iron industry because it is by far the largest consumer of coke.

The fact that blast-furnace iron is delivered in a molten state indicates at once that it is a different product from the infusible iron yielded by the so-called

[2] Further details of the recovery of potash from blast-furnace gases are given in Chapter IX.
[3] Chapter IX.

direct processes which have been referred to above. Instead of being soft and ductile, it is extremely hard and brittle, characteristics which, with its low melting point, depend upon the fact that instead of being nearly pure iron, it contains from four to more than six parts in a hundred of other substances, including carbon and silicon, together with minor amounts of sulphur and phosphorous and usually some manganese.

The metal, as it comes molten from the furnace, is either sent directly to another furnace for conversion to steel or to malleable iron or is put into marketable form by being cast into bars known as pigs. Approximately one-sixth of all the pig iron produced is destined for the foundry without further manufacture, the remaining larger proportion being suitable for making malleable iron or steel, the essential properties of which depend primarily upon the amount of carbon contained in the finished metal. Malleable iron is derived from pig iron by oxidizing or burning out the impurities, including all the carbon. Formerly in order to make steel soft iron was made to take up desired amounts of carbon by prolonged heating at a moderate temperature in contact with charcoal, or by first bringing about this absorption and then melting the product. But these methods are so expensive and so ill adapted for large-scale operations that it seems impossible that they could ever have been developed to furnish the great quantities of steel that are required today; creation of the age of steel was reserved for new processes by which pig iron could be directly converted into superior metal. The first revolutionary invention was that of Bessemer, who developed the idea of ridding molten pig iron of its impurities by blowing air through it. Working with metal derived from ores low in phosphorous, Bessemer suc-

ceeded in producing by his converter process what would now be called mild or soft steel, which contains enough carbon to keep it fluid until it can be poured but too little to render it susceptible of being hardened and tempered. Next, through an invention credited to David Mushet, temper steels were made by the device of adding carbon in predetermined amounts after the purification of the metal by blowing. But the converter process, which came to be rather extensively employed after 1856, was still limited in applicability because it required pig iron containing no more than minute amounts of phosphorous, and it remained for Thomas and Gilchrist to show that it could be so adapted as to enable removing phosphorous when the proportion of this element was at least above two per cent. This was accomplished by the device of lining the converter with calcined dolomite, a variety of limestone, and adding lime to the charge under treatment. Because of the chemical nature of the lining the Thomas process is known as the basic converter or basic Bessemer process, the original process of Bessemer being distinguished as the acid converter process. But for the success of the Thomas process large supplies of iron ore in Sweden and Russia and especially in Central Europe that are now available could not have been utilized for making steel, and the whole trend of affairs in Europe would have been altered. Had this process been developed prior to 1871, thus establishing the great value of the ore deposits of Lorraine, it cannot be doubted that Bismarck would have taken Belfort and Verdun from France, and with the tenure of these strongholds would have assured Germany in the indisputable possession of all the iron resources of the Moselle basin. It has been said that Thiers made possible the successful defense against the German aggressor in 1914

by saving Belfort for France in 1871. Had the Treaty of Frankfort given Belfort to Germany, it would seem that the latter could never have been worsted in war, and had the whole minette ore field been already in Germany's possession, one of her great incentives to the late war would not have existed.

Until within a few years, when electrically heated steel furnaces have come increasingly into use, the only rivals of the converter processes were the open-hearth steel-making processes, of which there are also two, distinguished as acid and basic from the nature of the furnace linings. Here the pig iron is melted in a roofed-over dish-like furnace by means of a gas flame, and the impurities of the crude iron are burned out in part by means of oxygen supplied by addition of iron ore and in part by an excess of air introduced with the fuel gas. The acid open-hearth process requires the use of pig iron quite as pure as that suitable for the original Bessemer process, but in the basic open-hearth process iron containing phosphorous can be treated, and its particular field is utilizing pig iron that is not suitable for any of the other processes. Because ores containing moderate amounts of phosphorus are more abundant than all the other grades taken together, with ever increasing demands for steel, the basic open-hearth process has come to occupy the premier place among all the methods of steel making. An advantage common to the two types of open hearth is that ore and scrap metal can be utilized along with pig iron, and in such quantities that, as has happened since 1916 in our own country, the production of all kinds of steel taken together may exceed the output of pig iron. Although the converter and the open-hearth furnace have grown from small beginnings, nowadays a converter may treat 300 tons of metal in

24 hours and an open-hearth furnace as much as 150 tons.

In making steel by any of the large-scale processes nearly all of the carbon is burned away, and the heat being adequate to keep the metal fluid, the latter is then recarbonized. For adding the required carbon, alloys of iron and managanese containing this element, known as spiegeleisen and ferro-manganese, are employed, and it is mainly in this step that manganese enters as an indispensable material for the iron industry. Here the Allies had a great advantage during the war, for they were able to obtain high-grade manganese ore from the great mines of India, Russia, and Brazil from the start, whereas the Central Powers were cut off from the usual foreign sources, and were obliged to mine extraordinary quantities of very low-grade ore at home and to utilize slags that contained manganese; it is supposed that they were also driven to the use of new alloys in the place of spiegel and ferro-manganese. By reason of the ship shortage in 1917 the problem of obtaining the manganese required for our own steel plants was a difficult one, but our known deposits of ore were made to furnish supplies that would have been impossible under normal competition with the mines of Russia and India, sources of manganese that had never been recognized as even possibilities were drawn upon and important economies were effected in the utilization of manganese alloys.[4]

The overweighing effect of carbon on the character of steel may be realized from the striking relation that in structural steel for each increase of one part of carbon in 10,000, the tensile strength is increased 1,000 pounds per square inch. Although ordinary steel may be de-

[4] More extended reference to the war-time problems of manganese and other alloy metals is made in Chapter VIII.

fined as an alloy of carbon and iron, the term "alloy steel" is now generally employed to distinguish iron products that contain besides carbon, which is a non-metallic element, amounts of one or more other metals that endow the composite metal with distinct combinations of qualities. The making of alloy steels began shortly before 1870, but the development of the field has taken place principally within the last 25 or 30 years, and recently these special products have become so important in many ways as to warrant the belief that this branch of the iron industry has scarcely passed the threshold of its useful possibility. Among the substances now in more or less common use for steel making, little brothers to iron, are manganese, nickel, cobalt, chromium, tungsten, molybdenum, vanadium, uranium, aluminum, silicon, and titanium. In general all of the steel-making processes are adapted for alloying, but as in point of nicety they differ inversely with the cost, any given steel will be made by the cheapest process consistent with the desired fineness and the required quantity of the product. The modifying metals are introduced just before pouring the steel into the ingot molds, and as a rule they are used in the form of rich alloys with iron called ferro-alloys, or, specifically, ferro-chromium, ferro-tungsten, and the like. In making ordinary steel ferro-manganese serves not only as a recarbonizer, but also as a scavenging agent effective in removing absorbed gases and dissolved oxides which, if not eliminated, would greatly detract from the quality of the steel. Here only a very minor part of the manganese remains in the re-carbonized metal, but by using an excess of the ferro-manganese the three purposes may be attained of re-carbonizing, purifying, and producing manganese steel, Of the elements listed above aluminum and titanium

serve as cleansers without producing useful alloys; manganese, vanadium, and silicon, and perhaps uranium, serve both as cleansers and as added components; nickel, cobalt, chromium, and tungsten are used solely for their alloy effects.

Armor plate and armor-piercing projectiles, metal possessing almost any desired coefficient of heat expansion, nonmagnetic steel and steel of extraordinarily high magnetic susceptibility, rails to stand more than three times the ordinary wear, steel for bridges and for structural uses in automobile making, forgings such as crank shafts, these are but a few of the alloy steels, many of which have been nothing if not revolutionary in their effects, each within some special field of modern industry. Cutting tools suitable for use in rapidly driven metal-dressing machines are made of the so-called high-speed steel containing tungsten or molybdenum as the principal alloying element, with minor amounts of manganese or chromium. So hard and tough are these tools that they can make very deep cuts, and as they hold their temper even when glowing hot, they can be operated at a very high rate of speed, the result being a most remarkable increase in the economy of running machine shops the world over.

With no more than mere mention that rolling and forging mills and fabricating shops are required for working iron and steel into usable shapes, let us consider shortly the principal raw materials of the industry. For each ton of iron produced from seven to 10 tons of material passes through the blast furnace. Although approximately two-thirds of the material entering is air, the figures given mean that for the production of 78 million long tons of iron in 1913, the world's carriers transported and the furnaces treated more than 250

million tons of iron ore, furnace flux, and fuel. Add to this the transport of the coal consumed in producing and working steel and of semi-finished products, and it can be readily seen that the iron business furnishes a goodly fraction of the freight burden in those countries that are large producers. In the United States these items may be roughly calculated as having amounted to some 6,000 million ton-miles in 1913.

In 1913 the world's production of pig iron amounted to about 79 million metric tons, which is 1.66 times the production of 1903 and 2.71 times that of 1893. The relative expansion of iron making in the principal producing countries is shown by the ratios of production for 1913 to that for 1893, respectively, as follows: Russia, 3.92; Germany, including Luxembourg, 3.18; United States, 3.71; Belgium, 3.06; France, 2.65; Austria-Hungary, 2.49; United Kingdom, 1.33. For France, Belgium, and the United Kingdom together the corresponding figure is 1.91, showing a rate of increase less than half that for Germany. In 1893 the combined iron output of the three countries named was nearly double that of Germany and Luxembourg, whereas in 1912 the output of the two groups was nearly the same, and in 1913 Germany produced 19.31 million tons compared with 18.12 million tons for the three Allies, or with 22.7 million tons if the production of Russia is added.

The comparative growth of the iron industry in the principal countries is shown in a summary way by the accompanying table of *per capita* production for the years 1890, 1900, and 1912, with which is given, in the right-hand column, the amount of pig iron *per capita* available for consumption in 1912.

It is to be noted that Belgium, with a *per capita* production of crude iron second only to that of the United

PER CAPITA OUTPUT AND CONSUMPTION OF PIG IRON IN PRINCIPAL PRODUCING COUNTRIES FOR SELECTED YEARS

(*In pounds*)

	Production			Consumption, 1912
	1890	1900	1912	
United States	304	425	690	685
United Kingdom	426	470	476*	415*
France	112	244	278	275
Belgium	280	322	676	900
European Russia	23	46	54	67
Germany	213	336	593	570
Austria-Hungary	45	45	67	95

* 1911.

States, imported practically all of the ore smelted, and besides using all of the output of her own furnaces required from abroad about 224 pounds of iron *per capita* to supply her foundries, steel works, and finishing mills. Thus Belgium offers a most striking illustration of the ironmaster's saying that ore goes to coal. In 1912 after balancing imports and exports Germany had 96 per cent. of the product of domestic furnaces available for further manufacture; for the United Kingdom the available balance was 84 per cent.; for France, more than 98 per cent.; and for the United States, above 99 per cent.

The statistics of iron making during four decades preceding the Great War are conveniently summarized in the following table, showing the aggregate production by ten-year periods for the world and for the countries or groups indicated, and also the respective rates of increase from decade to decade. The data given in the table have been used in constructing the diagrams presented in Figures 3 and 4 (pages 116 and 117).

In Figure 3 the progressive changes in the relative standing of the principal iron-making countries has been

PRODUCTION OF PIG IRON AND RATES OF INCREASE BY DECADES

(In million metric tons)

	1873	1883	1893	1903	1913
World:					
Quantity	126	167	240	441	622
Rate of Increase	....	1.30	1.47	1.71	1.51
United Kingdom, France and Belgium:					
Quantity	73.3	93.8	92	120	154
Rate of Increase	....	1.26	0.98	1.30	1.28
Russia:					
Quantity	3.3	4.3	8	22	31
Rate of Increase	....	1.3	1.83	2.75	1.41
United States:					
Quantity	16	31	69	128	248
Rate of Increase	....	1.93	2.22	1.85	1.95
Germany:					
Quantity	13.6	24.3	43	74	140
Rate of Increase	....	1.78	1.76	1.76	1.86

graphically shown by plotting their proportionate contributions to the world's iron supply by decades. From having contributed 60 per cent. in the decade ending 1873, the four countries of the Allied group furnished about 35 per cent. in the third, and only 30 per cent. in the fourth decade. In the meantime the share of the United States increased from about 13 to 40 per cent., and that of Germany from 9.5 to above 22.5 per cent.

In Figure 4 the production figures are plotted as ordinates in such a way that the line joining any ordinate with the corresponding one next in succession is more or less sloping as the rates of increase are higher or lower. By plotting production by decades rather than by years, unsystematic irregularities are eliminated and general trends are brought out in a definite manner. For the iron output of the world the diagram shows at a glance that the rates of increase were higher for the later than for the earlier decades, a relation which may be taken to

suggest that the industrial world is still far from the state of being saturated in respect to iron.

High and almost steady rates of expansion are shown by the graphs for the United States and Germany, whereas the output of the three industrial Allies increased at low rates, which were not steady until after the decade ending with 1893. Although any forecast of the future would be hazardous, it is of interest to note

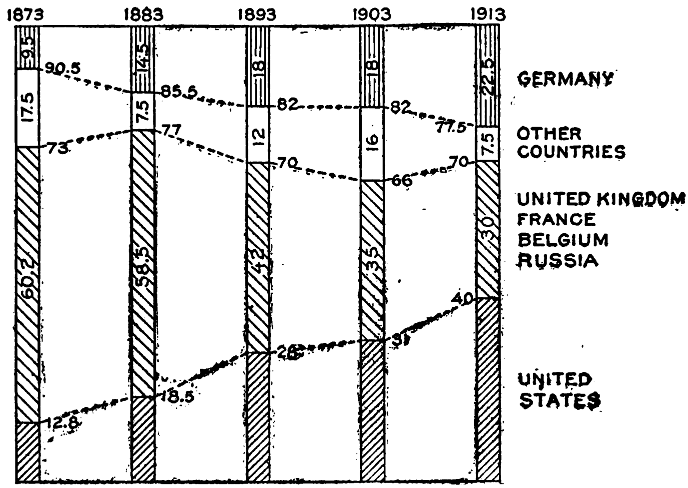

FIGURE 3. PERCENTAGES OF THE WORLD'S PIG IRON PRODUCED BY THE UNITED STATES, THE ALLIES, AND GERMANY IN THE DECADES ENDING 1873 TO 1913

that extension of the graphs shown in Figure 4, using the slopes that are characteristic for the decade ending with 1913, would indicate an iron requirement for the decade ending with 1923, of 450 million tons for the United States, 350 million tons for the three Allies and Germany together, and 935 million tons for the world. At the assumed rate the aggregate production for the five-year period just closed would have been 430 million tons,

whereas the attained output is estimated at 350 million tons, leaving an apparent deficit of 80 million tons for the world at the beginning of 1919. Thus, if both the indicated shortage and the assumed normal demand are

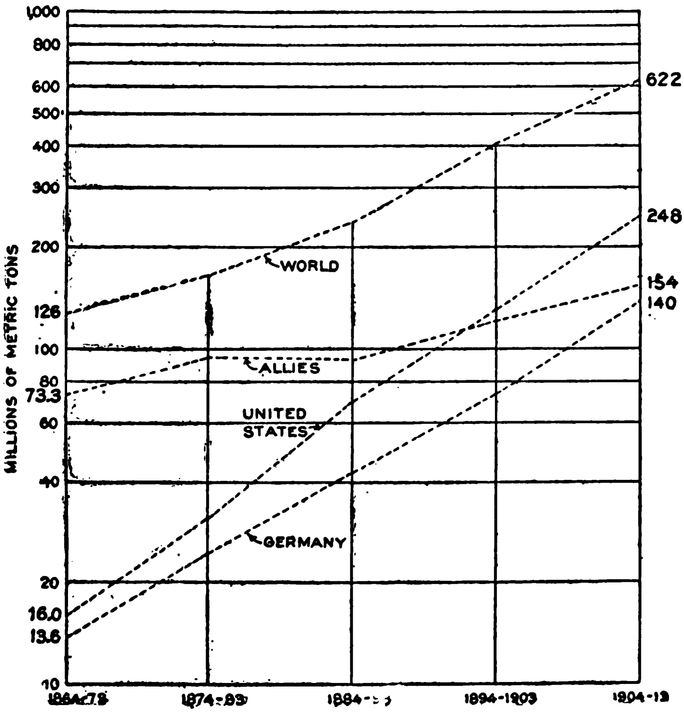

FIGURE 4. OUTPUT OF PIG IRON BY DECADES ENDING 1873 TO 1913 IN THE WORLD, THE UNITED STATES, GERMANY, AND THE UNITED KINGDOM, FRANCE AND BELGIUM TOGETHER. GUIDE LINES OF GREATER SLOPE CORRESPOND WITH HIGHER RATES OF INCREASE

to be met, during the next five years the blast furnace of the world must turn out in the neighborhood of 585 million tons of iron. According to the same method of estimation, the share assignable to the United States for the years 1919 to 1923 would be 285 million tons, or 48

per cent., and for the United Kingdom, Belgium, France, and Germany together, 245 million tons, or 42 per cent. The estimated requirements could be met only if the present furnace capacity of the world were to be fully utilized in 1919 and thereafter increased yearly at a rate of about seven per cent., compared with the statistical rate of about five per cent. for the decade ending with 1913. The United States could provide for her apparent prospective obligations only by increasing capacity at a rate above 10 per cent., compared with the statistical mean rate between 1903 and 1913 of about seven per cent. That any such increased rates of expansion can be attained before several years have elapsed may be seriously doubted, and in view of the enormous diversion of iron from peaceful industry during the period of the war, it would seem very unlikely that the accumulated iron deficit will be fully made up even within a period of ten years.

The principal raw materials required for iron making are ore as a source of metal, coke for fuel, and limestone for flux. Fluxing materials are usually at hand, so that, in general, the prime necessities for the maintenance of an iron industry are available supplies of ore and of coal suitable for making coke. Reference to Figure 16 (Chapter XI) will show, not only that the world's principal reserves of iron ore lie within the north Atlantic basin, but that the same great region possesses large reserves of coal. If the whole region is considered, the coal deposits are found to be less widely distributed than those of iron ore, and the further observation is to be made that nearly all of the world's iron smelting is done in or near regions where coking coal is mined. So generally applicable is the well known saying "ore goes to coal" that we find such countries as Sweden and Spain, both possessed of

great reserves of rich ore, supporting only negligible industries of their own, but sending millions of tons of iron ore to countries more favored in the possession of readily available fuel, and in the United States ore from the principal iron mining region is carried more than a thousand miles to the smelting furnaces. The outstanding principle back of this rule is not, as might be imagined, that more coal than ore is required in making a ton of iron, for the reverse is true, but rather the fact that many advantages accrue if the iron is produced near its market, which will be where industry is both varied and dense, as it tends to be where cheap coal can be had for generating power.

When the whole field is viewed, it is somewhat surprising to discover that there are so few districts wherein the resources of coal and iron are at all in balance, and that so far as industrially developed countries are concerned, only the United States has resources that insure an essentially self-contained industry. Looking to the future, no country in Europe that is likely to become a significant factor in supplying the world's iron, with the possible exception of the state that may be erected in the southern part of old Russia, can be regarded as having even approximately balanced resources of iron ore and coal. Germany would have approached this nationalistic ideal had she prevailed in the war and carried out her obvious design of annexing the iron fields of eastern France. Norway, Sweden, Spain, and Italy have ore but no fuel; Belgium has good coal but no ore deposits that can compete against supplies from abroad. France, though bereft of Lorraine by the Treaty of Frankfort, had before the Great War a marked overbalance of ore compared with coal, whereas before the war, even with the product of Lorraine, Germany was getting nearly half

of her yearly quota of iron from imported ores. Having now lost the ore fields of Lorraine, Germany's reserves of iron become inconsiderable in comparison with those of coal. On the basis of estimated ore reserves the United Kingdom might be regarded as potentially self-sustaining, but in recent years the tendency has been in quite the opposite direction, and so long as competition is offered by the countries of continental Europe, the British Isles are likely to depend more and more upon Sweden, Spain, and northern Africa to supplement home supplies of ores which are comparatively rather low in their content of iron.

That the United States possesses a self-contained iron industry sufficient for her own needs results primarily from her great geographic expanse. Alabama presents rather ideal conditions in the close proximity of iron ore, coal, and limestone deposits, but our greatest ore fields, lying west of the Great Lakes, are farther from the principal smelting districts in Ohio and Pennsylvania than are the iron mines of Sweden or Spain from British or German furnaces. Although their product had to be carried to industrial centers in Ohio and Pennsylvania, the bulk of it fully 200 miles by land and nearly 1,000 miles by water, the mines of the Lake district had marketed no less than 900 million tons of iron ore when navigation closed in 1918. To a greater degree than anywhere else in the world, the iron industry of the United States has been developed in accordance with the principle that production economy results from well coördinated large-scale operations in the three fields of mining, transportation, and smelting. The high degree of centralization that has been reached throughout the industry may be indicated by the fact that with only 333 furnaces in blast in 1916, the output of pig iron in this country

was almost 40 million long tons, whereas in 1881 no less than 455 furnaces were operated to produce four million tons of iron, the average furnace output having increased from 9,000 tons a year to 10,000 tons a month. For the United Kingdom in 1912 the output per active furnace was 28,000 long tons per year, and for Germany in the same year it was 55,500 long tons.

In the last analysis cheap iron means a large output per man employed, and by this test the United States undoubtedly stands well ahead of the nearest competitor. In the field of mining our premier position is shown by comparison for various countries of the yearly output per man engaged in mining in terms of iron contained in the ore produced, the comparison being based on statistics for 1912 and 1913:

	Metric tons
United States	590
Rest of world (estimated average)	230
Sweden	400
Germany	201
German Lorraine	378
France	304
French Lorraine	374
United Kingdom	230
Spain	140
World average	320

The output of 590 metric tons or about 580 long tons of iron per miner, which corresponds with an ore output of 62 million tons for the United States in 1913, was doubtless considerably exceeded in 1916, when in spite of a deficient supply of labor the iron-ore production amounted to 75 million tons. Such results have been attained very largely through the development of new systems of mining, particularly suited for working the immense iron-ore deposits of the Lake Superior district. There engineering skill has been utilized in a most far-seeing way in the planning, installation, and operation of

great mining plants; improved methods and mechanical devices supplement mere brawn; the use of vast capital renders labor correspondingly efficient.

The importance of cheap mining is, of course, not to be minimized, but with the Lake district furnishing considerably more than eight-tenths of the iron ore used in the United States, the realization comes that without the possibility of cheap transportation furnished by the Great Lakes our iron business must have been very different from what it is. With efficiency as the keynote of industry, hardly any greater attainment can be pointed out than the efficiency of ore handling and carriage between the producing mine and the consuming furnace. Seven hundred miles of superbly equipped railroad serve the iron ranges of Minnesota, Wisconsin, and Michigan. The loading docks at upper and the delivery docks at lower Lake ports are marvelous achievements of engineering construction, and the vessels of the ore fleet represent what would seem to be almost the culmination of evolution toward fitness were it not that the stages of this evolution of only 50 years must be remembered. Train loads of ore are dumped into pockets and spouted into the ship's hold at the rate of 10,000 tons in half an hour. With no time lost in loading, after a journey of four or five days the vessel arrives at the receiving dock, is discharged inside of half a day, and is off on the return voyage. Because navigation on the Lakes is closed for five months of the year, in order to have a steady supply of ore available, provision for storage is made both at the receiving docks and at the furnaces. By December the aggregate stock pile must contain 25 million tons of Lake ore. In 1913 the rate for ore carriage by water and for unloading was 50 cents a ton, an average of less than seven-tenths of a mill per ton-mile. This charge we may

compare with, say, five mills as an estimated minimum for what the railroads might do if put to it, and then draw the conclusion that the Great Lakes waterway is the foundation of our position as the world's greatest producer of iron and steel.

All along the line, in mining, transportation, and smelting, the principle at the bottom of progress in iron making in this country has been the characteristic policy of scrapping any machine or system just so soon as a better machine or system was offered. The studied employment of capital is made to increase the productive capacity of personnel, and thus to make high wages an economic possibility. In 1913 the world's output of pig iron amounted to 79 million metric tons, of which North America produced above 41 per cent., and Europe somewhat more than 58 per cent. The proportions furnished by the principal producing countries were: United States, 40; Germany, 24.5; United Kingdom, 13.5; France and Belgium together, 10; Russia, nearly six, and Austria-Hungary, three per cent.

Although the world's production of iron in 1913 was the largest that had been reached up to that time, everywhere the year was one of falling prices. Altogether, production was less in the second than in the first half of the year, and less again in the first half or 1914, but in the face of serious declines in America, the United Kingdom, and France the trend of production in Germany was generally upward through 1913 and for two months in 1914. In February, 1914, the furnaces of Germany and Luxemburg made the record output of 1.77 million tons, but beginning with March production declined, and the aggregate for the six months ending with June was somewhat below that for the previous half year. Thus, finally, Germany's iron barometer had registered

the generally unfavorable industrial outlook of a world which was unwittingly on the verge of all-absorbing war.

In the United States the pig-iron outlook for July, 1914, though somewhat greater than the low records for February and March of the same year, was less than the output for any other month as far back as July, 1911. August showed a slight improvement, but after this there was a steady decline which continued through the remainder of the year.

Recovery from the shock of war abroad began in January, 1915, and continued throughout the year, so that the rate for December reached 3.2 million tons, or more than double that of the preceding January. During the same period the monthly rate of steel production was trebled, and when the year closed 10 blast furnaces and more than 90 open-hearth steel furnaces were under construction. Although the direct effect of foreign orders during 1915 was important, as seen in the increase of our exports of iron and steel products from 1.5 million tons in 1914 to 3.5 million tons in 1915, of still greater influence in its stabilizing effect upon the iron market was a general expansion of industry resulting from increasing trade with those belligerents that had access to our ports and with neutrals seeking goods that they were not able to get from former sources because of the turmoil in Europe.

The high monthly rate of pig-iron production attained at the close of 1915 was slightly bettered in the average for 1916, and the record for the latter year was nearly one-third more than the output in 1915, or 39.4 million tons. The production of steel ingots and castings exceeded 42.7 million tons. The share of the world's pig-iron contributed by the United States in 1916 was slightly more than half. For the year our exports of products and manufactures of iron and steel reached 6.1 million tons,

an amount 60 per cent. greater than in 1916, four times the tonnage sold abroad in 1914, and nearly four-fifths of the total finished steel produced in the United Kingdom in 1916.

The needs of the Allies had created new markets for our iron products both abroad and at home, and having increased its capacity both for the production of metal and for its manufacture, the iron industry as a whole was in a way prepared when Uncle Sam threw his hat into the ring. Thus, at the beginning of 1917 our furnace capacity appears to have been adequate for the production of more than 42 million tons of pig-iron, but because of many unfavorable factors, the most important of which was a shortage of coke for smelting, the output of pig-iron for the year was only 38.2 million tons, or not quite as great as the output for 1916. The production of steel ingots and castings was about 45 million tons, or more than two million tons more than in the preceding year. The exportation of iron wares was greatly curtailed as the result of Government embargoes, but in spite of this a somewhat greater tonnage went abroad in 1917 than in 1916. Striking features of the year were the priorities given to Government orders in every branch of the industry, the ruling of President Wilson in July that our associates in war should pay no more for steel than domestic buyers, in September the fixing of prices by agreement between the producers and the War Industries Board, and in December a marked falling off in production connected with the congestion of railroad transportation.

Except for two bad months at the start and a noteworthy decrease of activity following the signing of the armistice, the year 1918 would have shown an increase in the output of both pig iron and steel over the two

years preceding, but with conditions as they were, the final record of about the same production as in 1917 may be regarded with no small degree of satisfaction.

Looking back over the period since our entry into the European conflict, perhaps the most remarkable fact in relation to our present subject is that all concerned failed at the start to realize the place that iron would occupy in meeting the situation. At the beginning of 1918 prominent trade journals stated that the Government needs for steel could hardly amount to as much as one-fifth the probable production, and predicted that after providing all that could be delivered abroad, the supply of finished steel would answer very well for the principal needs of consumers at home. Contrary to this outlook, by April the members of the Iron and Steel Association were taking a formal pledge to produce every possible pound of metal, and before July an estimate of requirements made by the War Industries Board was greater than the physical capacity of existing works and far beyond the practical capacity of the industry, handicapped as it was by deficient supplies and inadequate personnel. Obviously the situation was most serious, and to establish the best balance possible a system of priorities and allocation was devised and put into operation by the War Industries Board, with the result that essentially all the steel produced was destined to those uses wherein it would best serve the single purpose of the country to win the war against Germany.[5]

It has been estimated that at the beginning of 1919 the blast furnaces of the United States, if fully manned and adequately supplied with raw materials, would be able to turn out at least 45 million tons of pig iron an-

[5] For a description of this system see, in this series, Louis E. Van Norman, *War Time Control of Commerce.*

nually, and that under like conditions our steel furnaces could furnish 49 million tons of ingots and castings. These figures show increases of 30 and 40 per cent., respectively, for pig iron and steel capacities in the five-year period since 1913, and indicate that the United States had almost exactly half the steel-making facilities of the world.

The full importance of iron in the strategy of industry, whether in time of peace or war, can be better appreciated if we review the status of iron making as Germany saw it. Compared with the self-contained iron industry of the United States, where expansion has not been at the expense of any neighbor nation, the Continental iron situation has been complex. In the long standing war plan of Germany the aim to cripple France at the beginning of conflict through the elimination of the greater part of her iron industry was a fundamental point. The greatest iron-ore fields of Europe lie in the old Lorraine and the contiguous part of Luxemburg, and therefore on the Franco-German frontier as the international boundary was fixed by the treaty of 1871. The term "oölitic" is applied to the ores of this region by the Germans because they are made up of small pellets of iron minerals cemented together so as to resemble fish roe, but by the French they are called "minette" ores, originally a term of contempt arising from the fact that the ores were worthless for making wrought iron or steel because of their high phosphorus content. The Thomas converter process, which was introduced about 1878, not only made them available for the production of steel, but led to the salvage of the eliminated phosphorus in the form of ground slag, which is used as a fertilizer.

As inventoried in 1910, the reserves of the entire minette region comprise nearly 40 per cent. of the total

estimated iron reserve of Europe. These reserves amount to 1,845 million tons of iron contained in 5,500 million tons of ore, distributed as follows: France, Department of Muerthe-et-Moselle, 3,000 million tons; Germany, annexed Lorraine, 2,330 million tons; Luxemburg, 270 million tons. Besides the metal, these iron ores contain a reserve of phosphorus which may be calculated as equivalent to not less than 400 million tons of Thomas metal containing an average of 17 per cent. phosphoric acid.

Before the war more than three-fourths of the iron ore mined in Germany proper came from annexed Lorraine, and four-fifths of the ore produced in the German *Zollverein* or customs union came from annexed Lorraine and Luxemburg. Moreover, nine-tenths of the iron ore raised in France came from the mines of the three neighboring districts of Longwy, Briey, and Nancy, in the Department of Muerthe-et-Moselle. The production records of the mines, blast furnaces, and steel works in the districts named for the year 1913 are given in the following table, together with the totals for France and for Germany with Luxemburg:

PRODUCTION OF IRON ORE, PIG IRON, AND STEEL IN THE MINETTE REGION FOR THE YEAR 1913

(In million metric tons)

	Iron Ore	Pig Iron	Steel
Meurthe-et-Moselle	19.6	3.5	2.3
Luxemburg	7.3	2.5	1.3
Annexed Lorraine	21.1	3.8	2.3
	48.0	9.8	5.9
France	21.7	5.3	4.6
Germany	35.8	19.3	18.9

In furtherance of the German plan to crush industrial France, the Briey basin was invaded even before war

had been declared, and within a few days thereafter the Longwy basin was occupied. Because these ore basins were within range of the great guns at Metz, the French made no serious attempt to hold them. In 1913 the Briey and Longwy mines furnished 17.8 million tons of iron ore out of a total of 19.6 million tons produced in the eastern Department of Muerthe-et-Moselle, the remainder of nearly 2.0 million tons coming from the Nancy basin which remained in French or American hands throughout the war. Although defeated in the Battle of the Marne, after the stabilization of the opposing fronts at the end of September, 1914, Germany continued in complete control of the coal-mining and iron-making industries of Belgium, and in France held, respectively, 68, 83, 80, and 75 per cent. of the country's capacity for producing coal, iron ore, pig iron, and steel, judging from the statistics for 1913.

That such inroads on the basal industries of Belgium and France did not lead to capitulation as early as the spring of 1915 may be taken as certain evidence that Germany was not prepared for a conflict that should last for more than a few months. A sudden onset and a staggering blow, followed by a dictated peace, appear to have been the only outlook that had been entertained by the German high command, but if the possible failure of this plan was contemplated, it may have seemed obvious enough that even with England engaged as the ally of France, Germany would be able to carry on much more effectively than her antagonists. To provide for her own absolute requirements and for those of France, England must needs produce approximately as much coal and steel as before the war, and under the stress of maintaining capacity in time of war the efficiency of working her mines and furnaces would certainly be low.

That the English iron industry was not daunted by the difficulties of the situation is shown by the iron statistics of the United Kingdom, as summarized in the appended table, the most striking feature of which is the steadily increasing output of steel during the first three years of the conflict:

UNITED KINGDOM IRON AND STEEL PRODUCTION

(*In million gross tons*)

	1913	1914	1915	1916	1917
Domestic ore	16.0	14.8	14.2	13.5	14.4
Pig iron	10.3	9.0	8.8	9.0	9.4
Steel	7.6	7.8	8.5	9.2	9.8
Per cent. of 1913	(100)	(102)	(111)	(120)	(127)

In recent years approximately 55 per cent. of the new iron produced in Germany and Luxemburg has been derived from home ores, and as it is estimated that about the same proportion of all iron products has been finally absorbed by home markets, it appears that the *Zollverein* was theoretically in position to provide for all strictly internal needs on the same scale as before the war without receiving any ore from abroad. Actually imports from Sweden were maintained during the war, and since some time in 1915 it is supposed that the Briey and Longwy districts supplied ore for German furnaces, so that with pig-iron production at no time as much as 70 per cent. of that for 1913, probably there was no need to work the German mines at above 80 per cent. of their pre-war capacity, and in 1916, the last year for which we had pig-iron statistics, it would seem that the output of the mines of Germany and Luxemburg need not have been more than 70 per cent. of the 1913 record. Germany's production of iron ore, pig iron, and steel for the years 1913-1916 is given in the following table:

GERMAN IRON AND STEEL PRODUCTION
(In million metric tons)

	1913	1914	1915	1916
Domestic ore..........	35.9	29.0*	28.0*	25.0*
Pig iron..............	19.3	14.4	11.8	13.0
Steel.................	18.9	14.9	13.2	15.5
Per cent. of 1913......	(100)	(79)	(70)	(82)

* Estimated and not including ore from French mines in German possession. In 1917 the pig-iron output was about the same as in 1916.

As more than 40 per cent. of Germany's output of iron previous to the war was destined for export in various stages of manufacture, it is clear that when foreign markets were cut off, all possible needs were amply supplied by the greatly reduced production of 1915, and as the capacity for consumption rose through the expansion of war industries, all demands could be met without any extraordinary difficulty because the necessary works were already at hand and trained operators available. Barring the possibility of a general economic breakdown, the masters of Germany were sound in their belief that the iron industry of the country had been made a dependable basis for military operations so long as the mines and works of annexed Lorraine could be kept going. By seizing the iron mines and furnaces of the Briey and Longwy basins, not only was the adequacy of the German industry still further insured, but the whole industrial fabric of France was shaken and the basis laid for doubling Germany's reserves of iron by adding the three ore basins of the Department of Muerthe-et-Moselle to the deposits taken from France in 1871.

Had it been possible to achieve the announced intention of annexing the region containing the minette ores of eastern France, Germany would have emerged from the war in possession of 45 per cent. of the estimated

iron-ore reserves of Europe, and, basing calculations on the statistics for 1913, would have been in position to produce 55 million tons of iron ore, or the equivalent of 18 million tons of pig iron, and 20 million tons of steel ingots. With imports from countries other than France on the same scale as before the war, the available iron ore would have been enough for a yearly output of 26 million tons of steel, an amount equivalent to 63 and 35 per cent., respectively, of Europe's and the world's production for the year 1913, or 26 per cent. of the estimated capacity of the world's steel works at the present time, and somewhat more than the combined 1913 production of Germany (including Luxemburg), Belgium, and the Departments of Muerthe-et-Moselle, Nord, and Pas-de-Calais in France. On the basis of the foregoing calculations the situation after the conquest of the ore fields of eastern France would have been that Germany could have supplied from her own mines 77 per cent. of the iron required in place of the 56 per cent. so supplied before the war.

But with respect to the conquest of Europe's iron industry an overweening ambition has been thwarted. Germany not only fails to acquire the coveted minette fields of France, but with Lorraine, mines that in 1913 produced 75 per cent. of her strictly domestic iron ore must be given up, and if, as seems inevitable, Luxemburg breaks away from the *Zollverein,* hardly more than 20 per cent. of the developed mine capacity of the latter will remain to Germany. The iron-ore output of German-Austria has been nearly half that of Germany without Lorraine and Luxemburg, but leaving this territory out of consideration a rough calculation indicates that for the production of 13 million tons of pig iron, or somewhat less than the capacity of the furnaces that will

remain to Germany after the treaty of peace, no less than 22 million tons of ore must be imported, compared with less than 15 million tons received from abroad in 1913, and four-fifths of the pig iron to be made would have to come from foreign ores.

Truly iron entered largely into the underlying strategy of Germany's attempted conquests: first, providing a reliable industrial basis for war; second, offering a means of quickly disabling France; and third, proffering a grand prize in the minette ores of Muerthe-et-Moselle, which if attained, would insure industrial supremacy against all rivals.

If the iron problems growing out of the war are considered with particular reference to France, it appears that with Lorraine regained the country's nominal iron-ore production would be 21 million tons from Lorraine, 19 million tons from Muerthe-et-Moselle, and two million tons from other districts, making a total of 42 million tons. In order to smelt all this ore and to convert the pig iron to products of finished steel, coal and coke would be required at least equivalent to 55 million tons of coal, an amount equal to 88 per cent. of the combined production of France and Belgium or of the entire consumption in France in 1913.

COAL SUPPLY OF FRANCE IN 1913
(In million metric tons)

Domestic production	41
Great Britain	10
Belgium	4
Germany	7
Total	62

If France were to mine the indicated amount of ore and be able to dispose of eight million tons to Belgium and Great Britain, in order to utilize the ore remaining

coal and coke would be required equivalent to 48 million tons of coal. Thus the coal needs of the country would be increased to not less than 93 million tons, and even if the northern districts could furnish their pre-war quotas, which of course will not be possible until the demolished mining plants have been restored, there would be the necessity of importing above 50 million tons of coal. Then, if commerce with Germany were to be interdicted, the needed imports must be sought from British mines, which could hardly meet an added burden which would raise their quota of export coal by approximately 50 per cent.

By annexing the Sarre basin, which lies just east of Lorraine, France might gain possession of mines having a developed capacity of about 18 million tons of coal per annum, but though the outlook for iron working would be improved, the industry would still be far from reaching a status of balance between supplies of ore and fuel. Nor could this seizure be so much as contemplated by the proponents of a lasting peace, for the Sarre basin under French control would be just such a festering sore as Alsace-Lorraine has been since the Treaty of Frankfort. Unless France should go so far as to take over the coal mines lying west of the Rhine, in Westphalia, no way appears open for her to become self-contained in the matter of fuel, and to the writer it apears that the solution of the iron problem presented by the outcome of Europe's war will be found in an arrangement between the two countries under which France will receive fuel from the collieries of Westphalia and the Sarre, while Germany will receive from the eastern Departments of France the minette ore needed for her iron blast furnaces. This is the solution which has been indicated by several French engineers and economists, including the

world-renowned geologist de Launay. It is the logical way out, and perhaps the inevitable one under the laws of economics which have ever proved stronger than the dictates of racial hostility.

CHAPTER

COPPER

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1905, one to 80; from 1906 to 1910, one to 75; from 1911 to 1915, one to 70. The rather uniform relative increase from 1880 to 1910 was due to the increase in the ordinary industrial uses, and no doubt it will continue as the utilization of electrical energy is extended. For 1912 the ratio was one to 72; for 1913, one to 79; for 1914, one to 66; for 1915, one to 61; and for 1916, one to 53; indicating that the proportion of copper to iron required in modern warfare is considerably higher than that required in modern industry.

The location of copper mines has never controlled the location of great industrial centers, and copper thus far has been mined chiefly at places remote from those in which it has been fashioned finally into the forms that serve man. Since large copper deposits are not present near large industrial centers, it is desirable, or, indeed, essential, that every large industrial community should in some way control a supply of copper outside of its geographic boundaries. It is thus evident that the location and distribution of the world's large copper deposits are of wide interest, and that the control of even the remote or relatively inaccessible deposits is of economic importance.

Whenever there has been a large increase in the demand for copper, the prospector, the miner, and the metallurgist have responded with new discoveries and improved processes of production that have afforded the needed supply. For example, the greatly increased demand for copper for the electrical industry was met by the application of the electric current itself to the refining of copper, and the new process considerably reduced the cost and improved the quality of the output. About the same time the adoption of the Bessemer process for producing metallic copper greatly simplified and cheap-

ened the treatment of sulphide ores, from which the bulk of the world's supply of copper must come. The recent increasing demands have been met in large part by improvements in milling methods or the mechanical means of separating the valuable ore minerals from the worthless material that accompanies them. These improvements have permitted the utilization of great bodies of low-grade, disseminated ore, which now yield a considerable part of the output. It is worthy of note that just as the Great War began to make unusual demands on the copper industry, the flotation process of concentration was being adapted to copper ores, so that nearly all concentrating plants were enabled greatly to increase their recovery of metal, and numerous mines were again operated that had not proved profitable with the less efficient methods of concentration. At nearly the same time that this improvement was made in the metallurgy of low-grade sulphide ores, the process of leaching copper from oxidized ores and precipitating it from the resultant solutions was put into successful operation on a large scale.

The enforced substitution of other materials for copper in some of the belligerent countries will probably result in the permanent adoption of substitutes for certain purposes. The Germans used rather extensively in the electrical industry a very pure zinc instead of copper, although it is admitted to be less satisfactory. Specially prepared iron also is said to have been used in the electrical industry to replace copper. Other materials have been very generally substituted for copper as building material, in domestic utensils, and even in bearings for machinery, although for bearings no substitute equal to bronze (an alloy of copper and tin) appears to have been found. For many uses copper has no equal that can be produced in abundance; for other uses the indestructi-

bility and attractiveness of copper and its alloys, brass and bronze, make it especially desirable. It is reasonable to expect, then, that copper will long be a metal of great, if not of vital, importance to every highly organized community.

So far as can be judged from past production and present developments, the Western Continent is greatly favored in the distribution of the world's deposits of copper. The Americas now yield more than 75 per cent. of the world's output. The Eurasian Continent, though it contains a large proportion of the world's population, is but meagrely supplied with copper, and its present production is less than 17 per cent. of the world's output. Of this Japan produces about one-half. The copper deposits of Africa contain an unknown amount, but some of them are large. Australia is moderately well supplied.

In the New World copper is very unevenly distributed. Most of the deposits are on the west side of the continent, extending from Alaska to southern Chile. On the east side of the continent only three districts that contain large deposits are known — the Lake Superior district of Michigan, the Sudbury district of Canada, and the Ducktown district of Tennessee. The large countries of North America extend across the continent and are thus well supplied with copper from deposits within their own boundaries; but if the areas east and west of the Mississippi Valley had remained separate political divisions, as they once were, the thickly populated eastern area would have been dependent upon outside sources for a large part of its copper supply, and the western area would have had a very large surplus. In South America, where the countries do not extend across the continent, this condition really exists, although its effect is not

now severely felt, for these countries have not yet developed large manufacturing industries. The countries of the Western Continent that have large known copper deposits are Canada, the United States, Mexico, Peru, Bolivia, and Chile. Others, such as Cuba and Venezuela, have relatively small known deposits, and it is possible that still others, such as Argentina, have large deposits that have not yet been developed.

In the Eurasian Continent but six countries are at all adequately supplied with copper from deposits within their boundaries; the requirements of the other countries must be met in large part from deposits elsewhere. Spain, Portugal, Norway, Russia, Serbia, and Japan can supply their own requirements, and all except Russia are exporters, although Spain and Portugal are the only countries that have known supplies largely in excess of their probable future demands. Germany contains large deposits, but her output has been far below her own needs in recent times. Italy, Sweden, and Austria-Hungary contribute small amounts. Great Britain and France are almost entirely dependent upon outside sources, although Great Britain was once the world's largest producer of copper, and the Swansea works, in Wales, are classic in the history of copper metallurgy.

In no part of Africa has a large manufacturing community been developed, so that almost the entire copper output of the continent is exported. South Africa has long been a steady contributor and doubtless will continue to contribute in the future. In recent years copper has been mined in the Belgian Kongo, and this region contains large deposits of copper ore.

The Australian continent seems to be amply supplied with copper and up to the present time has been an exporter. The development of manufacturing in Aus-

tralia, however, is constantly requiring larger amounts for use at home, and unless additional deposits are discovered, the continent cannot be depended upon for large exports.

Several of the great copper-producing districts have contributed rather steadily to the output for scores and

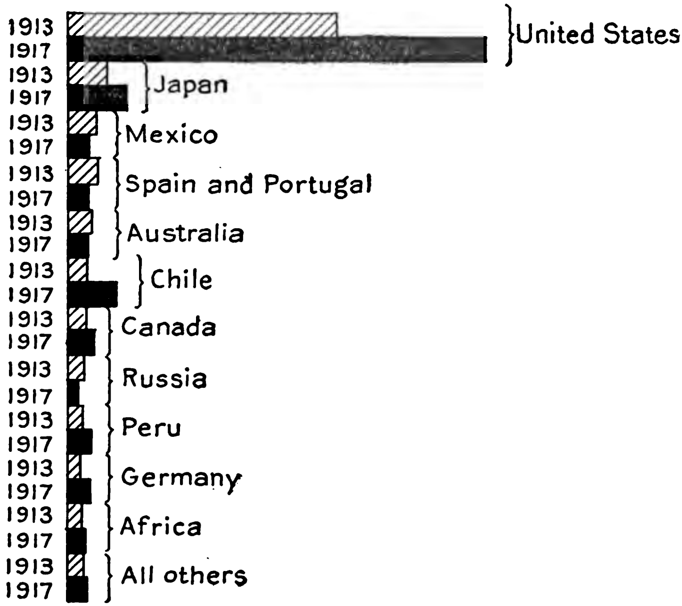

FIGURE 5. RELATIVE IMPORTANCE OF COUNTRIES IN THE PRODUCTION OF COPPER, 1913 AND 1917

even hundreds of years, especially certain districts in Spain, Germany, and Japan. Yet there has been a continual shifting of the relative productiveness of the districts, and this is likely to continue in the future. In the early part of the last century Great Britain was the largest producer. About the middle of the century this distinction passed to the western coast of South America,

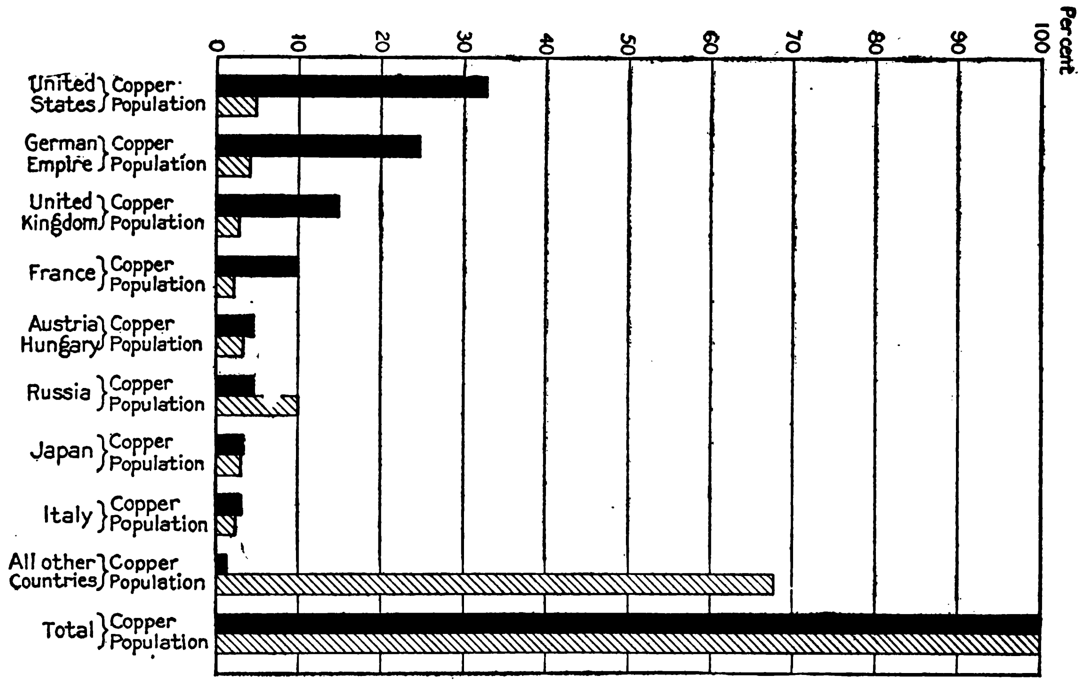

FIGURE 6. PERCENTAGES OF THE WORLD'S OUTPUT OF RAW COPPER USED BY THE PRINCIPAL MANUFACTURING COUNTRIES BEFORE THE WAR AND PERCENTAGES OF THE WORLD'S POPULATION IN THOSE COUNTRIES

where it was held until the early eighties, when the rapid expansion of the industry in the United States and a coincident decline in South America brought the United States into the first place. This position it has since held, and seems likely to hold for many years, although the production of other countries, as South America, Africa, Russia, and Japan, will probably show increases. The accompanying diagram (Figure 5) shows the output of the principal copper producing countries in the year before the war began (1913) and in 1917.

Copper has many uses, and different peoples show decided preferences for particular uses. The Chinese, for example, use it largely in coins; some European nations have used it very extensively in building and for household utensils. In times of peace, however, it is most used in electrical work and in machinery, so that the consumption of copper by a people is largely proportional to the extent to which they have adopted modern inventions. The average annual consumption of copper *per capita* of the world at the beginning of the war was about 1.3 pounds, but the consumption was by no means uniformly distributed throughout the world. The consumption *per capita* in highly industrial communities before the war was probably four to five times the average; the native of the South Sea Islands, on the other hand, may have been content for a lifetime with none or with but a few ounces to ornament his person. Moreover, copper is made into usable forms in only a few countries, and the finished products of copper, brass, bronze, or parts of machinery, are sent to the non-manufacturing countries. Thus, although Chile and Peru are large producers and exporters of copper, they obtain most of their manufactured copper from North America and Europe. Figure 6 shows the relative con-

sumption of copper by the principal manufacturing countries and the relative population of those countries of the beginning of the war. At that time Germany led in copper manufactured *per capita,* with about 8.5 pounds; the United States was second, with about 8.1 pounds; the United Kingdom was third, with about 6.7

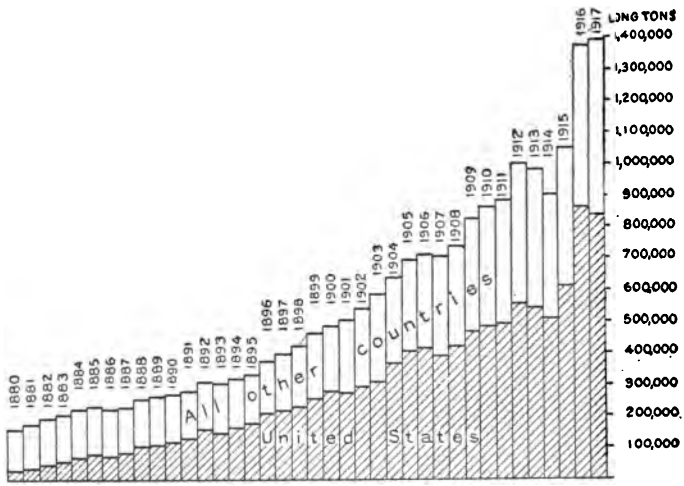

FIGURE 7. PRODUCTION OF COPPER IN THE UNITED STATES AND IN THE WORLD, 1880-1917

pounds; and France was fourth, with about 5.8 pounds. Russia at that time was manufacturing but little more than half a pound *per capita.*

It is evident from this brief survey of the sources of supply and the points of consumption that in the future, as in the past, copper will be an important article of international trade.

The world's production of copper and that of the United States have practically doubled during the last ten years. In 1916 the United States alone produced

nearly as much copper as the entire world produced but six years earlier. The accompanying diagram (Figure 7) shows the growth in the world's production of copper since 1880. The very rapid increase can be attributed largely to the demand resulting from the expansion of the electrical industry and to the more general use of machinery, and the requirements for these uses are certain to increase still further. The invention and improvement of methods of transmitting electrical energy have contributed largely to the recent increased use of copper in the electrical industry, and further improvements are certain to be made as water power is utilized more and more both for transportation and for manufacturing. The congestion of transportation that occurred in practically all the belligerent countries during the war has emphasized the desirability of eliminating as far as possible the transportation of coal to be used for power by burning it near the mine to generate electrical energy which can be transmitted by wire to the points where the power is required. Such generating plants are now in operation at Windsor, West Virginia, Warrior, Alabama, and elsewhere in the United States, and a comprehensive plan for the same purpose has been proposed in England.

It can safely be assumed, then, that the demand for copper will continue in the future to increase, the amount required being dependent upon the rapidity with which the electrical industry is developed both in regions where electricity is now largely used and in regions where it is almost unknown. If the Chinese, for example, should adopt modern improvements in the next quarter of a century to the extent that the Japanese have in the last quarter, their increased use of copper would add largely to the world's demand for the metal,

and if the future average *per capita* use for the world should be raised to the present average use among the principal western peoples, the requirements would be enormous. Of course any such world progress in industrial expansion will be gradual, but as this expansion is what the world is striving for, such progress is sure to be made, especially rapidly following the Great War.

The large prospective increase in the demand for copper makes the future supply a subject of great interest; yet this is a subject on which we have but meagre data and on which the history of the industry does not shed much light. Various methods of estimating the reserves of copper available for future use have been employed, but as the results obtained by most of these methods would indicate a constant and very large increase in the apparent supply, regardless of the amount being extracted, the validity of the methods and the accuracy of the resulting estimates may be doubted. In 1880, for example, the known reserves of copper in the Western Continent were small and some of the larger South American deposits were regarded as approaching exhaustion. By 1890 exploration and improved methods of smelting sulphide ores greatly enlarged the apparent future supply in the United States. During the nineties improvement in smelting continued, and the extension of the use of mechanical concentration to the lower-grade sulphide ores further increased the quantity of copper ore available and pointed the way to the great extension that was to follow. During the first decade of the present century the continued improvement and the wider application of methods of concentration made it possible to mine profitably material that had been considered worthless, and very greatly enlarged the possible future production by opening for exploitation the im-

mense bodies of disseminated ore that have since contributed so largely to the supply, as well as by adding greatly to the quantity of ore available in deposits of other types. In the present decade the introduction of the flotation method of concentration and the successful use of leaching processes has further augmented our available supply of ores by adding millions of tons in deposits that before had not been worked, or had been worked only for their higher-grade ore and the mines producing which had been regarded as practically exhausted. Thus, regions like the west coast of South America, which at the beginning of the century were regarded as nearing exhaustion, are now known to be only entering on their productive career. In addition to the available ore thus added to the supply, a large part of the waste material of earlier operations is now being worked to recover the metal that escaped the less efficient methods.

The advance in metallurgy is shown by the continuous decrease in the average amount of copper profitably recovered from each ton of ore, indicating that it has been found possible to work ore of lower and lower grade. Thus, in the decade 1907-1916 the average amount of copper recovered from ores decreased from 42 pounds to 34 pounds to the ton, a decrease of about 20 per cent. Of course, such a lowering of the grade of ore that could be treated profitably added greatly to the amount of ore available for treatment. For a large part of the decade the metallurgic change consisted in more extensive operation. Mills with capacities undreamed of a few years earlier were constructed, as, for example, those of the Utah Copper Company, capable of treating more than 30,000 tons of ore daily. In that decade the amount of ore treated annually increased 185 per cent., but the

average percentage of recovery of the metal contained in the ore probably showed no average increase and in some operations was very low. During the later part of the decade especially much attention was given to intensive metallurgy, and some companies have shown wonderful improvement in the percentage of recovery. For example, by reconstructing its plant the Anaconda Copper Mining Company increased the percentage of the metal won from the ore from 82 to 96. The demand for copper to meet the needs of the war made it necessary to get a large output of copper quickly at the expense of high recovery and retarded the application of intensive methods, but during the next decade there is certain to be a large increase in the percentage of metal obtained from the ores, as well as a recovery of much of that which was temporarily lost through the stress produced by the war.

Progress in metallurgy has been emphasized thus far in this statement, but like progress has been made in methods of mining which also has added to our possible supplies. The advance in mining is best indicated by the fact that the average amount of copper produced per man per day in the copper mines of the United States steadily increased from about 75 pounds in 1912 to more than 100 pounds in 1916, an increase in five years of about one-third in the average miner's ability to produce copper. In other words, an increase of 20 per cent. in days worked per year produced an increase of 62 per cent. in copper mined. This increase is due in part, of course, to the increase in production by mines that extract their ores by steam shovels from open cuts and make a relatively very large production per man. The copper producers of Utah thus increased their average production per man per day from about 80 pounds in

1912 to 175 pounds in 1916 — that is, they more than doubled the productiveness per man in the five-year period. In fact, although fewer men were employed in mining copper in Utah in 1916 than in 1912, the production had increased more than 100,000,000 pounds.

Mines that employ underground methods, however, are also able to make very large production. For exemple, the Inspiration Consolidated Copper Company of Arizona, according to its annual report, produced more than 350 pounds per man per day in 1917, although during a part of the year the operating conditions were unfavorable. Even in old districts, such as those in the Lake Superior region, where the mines are becoming increasingly deep, surprising results have been achieved in maintaining and even increasing the amount of ore mined per man. The decided improvement in metallurgy also makes the copper produced per day notably higher, and if the production from old tailings is included, the increased production per man in the Lake Superior region increased 25 per cent. during the five-year period from 1912 to 1916.

In the Butte district great improvements in mining have been made in recent years. The substitution of hydroelectric power for steam power in hoisting, the extensive introduction of electric haulage, and other improvements have reduced the cost of extracting ore, although the mines of Montana have not shown a gain in copper produced per man.

Some of the smaller mines and districts have not been able to maintain their production per man, and of course the fact must be recognized that a time will come in the life of every mine when it will take an increasing amount of labor to get out a given amount of metal. The efficiency of production in the United States as a whole,

however, as compared with that of any other large producing country, is so high that our own industry has little to fear from outside competition, although this fact should not lessen and evidently has not lessened efforts for improvement.

The amount of metal that a day's work will produce differs greatly in different mines. The accompanying diagram (Figure 8) shows approximately the amount

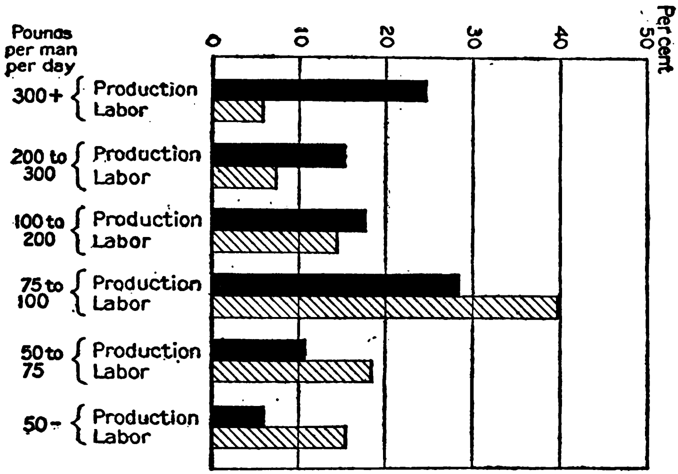

FIGURE 8. RELATIVE AMOUNT OF LABOR EMPLOYED AND COPPER PRODUCED BY DIFFERENT CLASSES OF MINES IN THE UNITED STATES IN 1916

of copper produced in 1916 by mines grouped according to the amount produced per day's work. Mines producing more than 300 pounds per man per day yielded nearly 22.5 per cent. of the copper produced; mines producing between 200 and 300 pounds, more than 14 per cent.; mines producing between 100 and 200 pounds, nearly 16.5 per cent.; mines producing between 75 and 100 pounds, more than 26.5 per cent.; mines producing

between 50 and 75 pounds, about 9.5 per cent.; and mines producing less than 50 pounds, about five per cent. In addition, about four per cent. was produced by small copper mines and prospects the labor efficiency of which is not definitely known but certainly did not exceed 30 pounds per man per day, and nearly 1.5 per cent. was produced from mines operated primarily for the production of other metals.

Of course, the machinery used in the very efficient mines must itself be produced by labor outside the mines. The man who operates a steam shovel is dependent upon more outside labor than the man who operates a hand shovel. Likewise, the man who operates a machine drill or churn drill or the man who operates an underground electric train has the aid of more outside labor than the man who operates a steel and "single jack" or the man who operates a push car. But even after these differences in contributory labor have been considered, there can be no doubt that the employment of human intelligence to operate machinery results in greater efficiency than dependence mainly upon man's strength to break, lift, and transport ore from the mines. It should be recognized, however, that all mines are not equally adapted to the employment of machinery, and that in one mine the production of 50 pounds of copper per man may represent more skilled and better management than the production of 200 pounds in a neighboring mine.

During the war it was essential to get the greatest possible production from a limited amount of labor. To transfer a man from the least efficient group of mines to the most efficient group would increase his productiveness more than 10 times; and if all the labor in the least efficient group could have been employed in the most efficient, it would have yielded an increase amount-

ing to more than half the copper produced in the country. If the men employed in the lowest group had been distributed among the higher groups in proportion to production, their efficiency would have been increased more than 300 per cent.

It is apparent that for the period of the war it was for the interest of the country that labor should be employed where it would be most effective, and that in so far as there was a shortage of labor, the less efficient mines should suffer while the more efficient should be given an ample supply. With the close of the war the necessity for getting the most from our labor became less acute, but certainly not less desirable, and it is a matter of the highest importance to the laborer himself.

There has been a growing tendency on the part of the laboring class to demand a larger share in the product of its efforts and the justice of its demand has been and is being very generally recognized. In a business like copper mining it is obviously impracticable to put labor directly on a profit-sharing basis, although it is now generally recognized that when the industry is prosperous the miner shall have a share in the good times. A significant point that is not always recognized by the miner is that the prosperity of the industry is quite as dependent upon the amount of metal that a given amount of labor will yield as it is on the price of the metal. If a mine is yielding 75 pounds of copper per day's labor and by the improvement of methods and the introduction of machinery is able to produce 100 pounds, it is apparent that the operating company is in a better position to consider an increase in wages. Thus the industry as a whole, by increasing its average productiveness per day's labor from 75 to 100 pounds in the period from 1912 to 1916, increased its ability to pay

wages. The miner must recognize that if he wishes larger wages and shorter hours, he must make his labor more effective, and that if by enthusiastically accepting or devising improved methods and mechanical devices his productiveness is increased, he may justly demand a corresponding increase in wages. If, on the other hand, the productiveness of labor decreases, the operating companies may be unable to maintain wages regardless of their desire to do so.

It is apparent, then, that both the metallurgist and the miner have been making rapid progress in their respective fields. The combined improvement is measured in part by the decrease in the cost of producing copper, although it is a common practice to utilize improvement in part by lowering the grade of ore rather than by increasing the profit per pound of copper. Unfortunately there is no record of the average cost of all copper produced, but a comparison of the records available indicates that before the period of high costs caused by the war there was a reduction in the costs. This reduction was due in part to the increasing amount produced by the new low-cost mines, but even old districts, like those of the Lake Superior region, made their copper for more than a cent a pound less in 1915 than in any other year since 1910.

It may seem that we have now approached the maximum of efficiency, but when we realize that from five to more than 30 per cent. of the metal in the ore is now lost in treatment, we must see that metallurgists will not rest content with their present accomplishments, nor is the miner of today satisfied with the efficiency with which ore is won. If during the last generation each year and each decade has seen an increase in the known supply of copper available for the future, we might conclude that

this increase may continue. No doubt it will continue for a time, but we shall eventually face a decreasing future supply, apparent as well as actual. Few copper mines have sufficient ore proved to maintain their present output for a quarter of a century, and the known supply in most mines will not last half that long. The discovery of new deposits and the development of old deposits, as well as improvements in recovery, will greatly increase the known resources, but if the whole world is to be supplied with copper to the extent that the metal is now used by the western nations, the copper to do it is not now in sight.

It should not be forgotten, however, that aluminum, and possibly zinc and iron, may be widely used instead of copper in the electrical industry. Before the war electrical energy was transmitted to the world's greatest copper camp through aluminum cables, although they have since given place to copper. Measured by its conductivity alone, aluminum at twice the price of copper is its equal, although copper has physical properties which make it superior to aluminum. Certain defects in aluminum as a medium for transmitting the electric current are being overcome, and as soon as its price becomes low enough, it is likely to replace copper in certain electrical uses, as it has already replaced it to a large extent in our kitchens.

For several years before the war the selling price of copper averaged about 14 cents per pound and the average cost was probably nine to 10 cents per pound, or there was a profit of four to five cents per pound. During the war the selling price of copper rose rather steadily, until late in 1916 and early in 1917 it was 30 cents or more per pound. Following this it receded somewhat, and on September 21, 1917, by agreement

Principal Features of the Copper Industry of the United States, 1907-1917

(000 *omitted*)

Year	Refined Copper, Primary	Secondary Copper	Smelter Production Domestic Ores	Imports
	Pounds	*Pounds*	*Pounds*	*Pounds*
1907........	1,032,500	....	868,900	252,600
1908........	1,137,900	....	942,500	218,700
1909........	1,391,000	....	1,092,900	321,800
1910........	1,422,000	....	1,080,000	344,000
1911........	1,433,800	214,000	1,097,000	334,600
1912........	1,568,100	275,000	1,243,000	410,000
1913........	1,615,000	273,000	1,224,000	408,700
1914........	1,533,700	255,700	1,150,000	306,000
1915........	1,634,200	392,200	1,388,000	315,600
1916........	2,259,000	700,000	1,928,000	462,000
1917........	2,428,000	....	1,886,000	556,000

Year	Exports of Metallic Copper	Domestic Consumption	Average Yearly Price per Pound	World's Production
	Pounds	*Pounds*		*Pounds*
1907........	508,900	487,700	$0.200	1,589,000
1908........	661,800	479,900	.132	1,683,000
1909........	682,800	688,500	.130	1,875,000
1910........	708,000	732,000	.127	1,903,000
1911........	786,500	681,700	.125	1,958,000
1912........	775,000	755,900	.165	2,259,000
1913........	926,000	812,000	.155	2,198,000
1914........	840,000	620,000	.133	*2,036,000
1915........	681,900	1,043,000	.175	*2,339,000
1916........	784,000	1,430,000	.246	*3,078,000
1917........	1,126,000	1,316,000	.273	*3,115,000

* From *Engineering and Mining Journal.*

between the Government and the producers the maximum price was fixed at 23.5 cents per pound. This continued until July 2, 1918, when it was advanced to 26 cents, at which price it remained until Government regulation ceased at the close of 1918.

During the advance in price the cost of production

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per pound and it had incre
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earth in the 13,000,000 miles of underground cables. Most of the copper thus employed will add as much to the efficiency, comfort, and pleasure of the next generation as it does to our own. So too will the copper that enters into electrical transportation, although the wastage in this use may be somewhat greater.

The preservation of copper and its conversion to other uses is well illustrated in the Central Empires, where the supply of new copper was very deficient during the war and the deficiency had to be met by taking copper previously in use. Thus roofs were stripped of their copper sheathing, and brass hinges, door trimmings, and other brass, bronze, and copper articles, much used by the Germans and Belgians in building, gave place to substitutes. Some of the copper employed in the telephone, telegraph, electrical, and transportation industries was replaced by substitutes and went into munitions. Articles of sentimental as well as of practical value were sacrificed, such as the household utensils of copper and brass that are so generally used in Germany, many of them highly prized as family heirlooms. Bells of churches and cathedrals in Belgium and northern France, as well as those in the Central Empires, which had summoned generation after generation to worship, were melted to supply the demands of war. It is reported that the monument which for three generations marked the place where the ambitions of Napoleon were shattered on the field of Waterloo was melted down for the copper derived from the French cannon of which it was made, which was thus again used for military purposes. It is perhaps not too much to hope that when scraps of metal are gathered from many battlefields and fashioned into a fitting memorial to commemorate the defeat, let us hope for all time, of the attempts of auto-

crats to exploit nations for the gratification o personal ambition, the memorial may contain some of the metal that represents sacrifices of useful, ornamental, and sacred objects, which thus again may serve mankind for generations to come, this time as a warning and an inspiration.

A second reason for not restricting the use of copper is that it may not be so essential to man at the end of the century as it is now; but whether it is or not we may trust somewhat to the ingenuity of our descendants to meet the demands that confront them.

The policy we should adopt in respect to copper is to see that there is no unnecessary waste. In the past the tailings from some mills and the slags from some smelters have been run into streams and wasted. The copper thus lost, if stored, not only would have increased our metal reserves, but would have been a source of large revenue to its owners. Such losses must be avoided. In view of our experience for many years, however, few engineers would now permit the waste of material containing a considerable amount of metal, for they too frequently have seen the waste material of one decade take on a large value in the next.

Perhaps a more vital question to us now is: What is the relation of supply and demand now that the war is over? The supply can be fairly well estimated. The producing capacity of the world is now considerably greater than it was before the war. In addition a large amount of copper that has been put into war material or was in process of manufacture into such material can be turned to peaceful uses. The copper that has been used in war, of course, is not recovered to the same extent as that which has been used in industry, but a large percentage of it is salvaged, and with the less strenuous

pressure following the war much metal will be recovered that has been neglected. With the demands for military uses cancelled, if production goes on without interruption, it would appear that a very large supply of copper will be available for industrial uses.

The extent of the demand following the war is more uncertain. In the large industrial nations, no doubt, an active effort will be made to restore devastated regions and to rehabilitate industries that have been neglected during the war. If industry is to approach the pre-war output in the European countries, it must employ all available mechanical means, as the man power for several years after the war will be much below normal in numbers and in physical ability. Such an increase in mechanical work means a corresponding increase in the demand for copper.

The Central Powers are doubtless largely depleted of copper and their requirements will be large. It is not at all likely that the copper that has been taken from private and public buildings will be replaced everywhere in kind, for copper utensils and building materials will be replaced by those made of other metals. Moreover, the necessity of using substitutes has doubtless led to the discovery of some the use of which will be continued and even extended to other countries. It seems doubtful, then, that the demands of the Central Powers immediately following the war will greatly exceed, if indeed they equal, their demands immediately before the war.

The commerce in copper has been controlled heretofore by various circumstances and methods. In the early part of the nineteenth century Great Britain was the leading copper-mining country, and for a long time after she ceased to be a large producer of copper ore, she maintained a measure of control of the industry

because much of the world's copper continued to be smelted at Swansea, Wales, though it was mined elsewhere. The development of the great native-copper deposits of the Lake Superior region about the middle of the last century marked the beginning of the dominance of the United States in the copper industry. The native metal of these deposits was easily freed from the accompanying minerals, and copper of very high grade was produced. The development of American smelting and the high toll charged by the Swansea works led to the treatment of ores near their sources, and the industry became scattered. The application of the electrolytic process of refining, however, has tended again to centralize it. The use of this process was rapidly extended in the United States, which soon led the world in the refining of copper and still maintains the lead. The copper-refining industry of the Western Continent is mainly concentrated on the northern Atlantic seaboard of the United States, although there are large refining plants at Tacoma, Washington, and Great Falls, Montana, a refinery has recently been opened at Trail, British Columbia, and the product of the Chile Copper Company of Chile is refined copper. In the Old World there has been no such marked tendency to localize the refining industry, and the present tendency in the Western Continent seems to be away from localization, although the economy of operating large plants will probably always cause the industry to be confined to the few places where such plants can be most advantageously located.

The manufacture of copper and brass in the Western Continent, like the refining of copper, has been confined largely to the northern Atlantic seaboard of the United States. As the West is becoming a greater user of

copper, however, the waste involved in transporting it across the continent for manufacture and back for use is apparent, and has been recognized by the establishment recently at Great Falls, Montana, of a plant for producing the simpler forms of copper manufactures, such as rods and wire. This practice, if extended, as it probably will be, must tend gradually to decrease the localization of the industry, at least the refining and manufacture.

In recent years copper has been marketed in this country through a few companies which act as selling agents for the many companies that mine, smelt, and refine copper. Such agents may or may not be directly connected with the producing companies. Most of the copper produced in the Western Continent is marketed through scarcely more than a dozen agencies, and a large percentage of it is handled by a much smaller number. This arrangement gives the producers rather close control of the industry, and a close control over the export trade is maintained by a company composed of the principal copper producers. Some of the selling companies have maintained close connection with foreign companies, and have been controlled, at least in part, by foreign capital. The German interests in three such companies have now been taken over by the United States Government. A number of mines in the Western Continent are owned in large part by European capitalists, but most of the copper industry of the continent is under the control of citizens of the Americas.

It is natural to ask whether it would not be good national policy, if there is likely to be a scarcity of copper 50 or 100 years hence, to retain our supply for use in this country. This question has many aspects and will not be discussed here. We must remember,

however, that we are not self-contained in respect to all our requirements, and that we must be willing to make exchanges. Moreover, as a worthy member of the community of nations we should exchange some of our plenty with those who need it and wish to be neighborly.[3]

The copper industry has long been distinctly international, and those who have guided it have been accustomed to view it as a world industry rather than a local or a national industry. The war will probably not change that view. In the past there have been changes in the stage of manufacture that our copper reached before it went into international trade, and similar changes will no doubt continue. As has been pointed out, it was once economical to send much of our copper abroad as ore, to be treated in European plants. As we gradually mastered the metallurgy of copper, our exports of ore decreased and our exports of metal increased. Finally, our metallurgical plants were made so efficient that copper was brought to the Untied States in various stages of treatment to be refined and re-exported.

Similar changes have occurred in respect to copper manufactures. There was a time when many of the manufactured products of copper we used were imported into this country as they are now imported into many other countries. With the growth of manufacturing we are making an increasingly greater quantity of finished copper products, although we still find it advantageous to import certain manufactured articles of copper. However, we are exporting from year to year an increasing proportion of our copper in manufactured form, and we shall doubtless continue to do so until

[3] For a discussion of national policy in respect to the control of raw materials see, in this series, W. S. Culbertson, *Commercial Policy in War Time and After.*

ultimately much of our exported copper may consist of manufactured products.

We are justified, therefore, in believing that the foreign customer who presents himself at our counter for copper will get it in the form that is most attractive to him. He can see here the raw material and the manufactured articles, and if we can give him the articles for less than it would cost him to buy the raw material and make them, he will take the articles. But if our manufactured products do not surpass or equal those of other countries in quality and meet competition in cost, we cannot expect and should not desire to continue to manufacture our copper here. In this industry, as in many others, we are in the field of international competition for the markets of the world, and it is our task to make American initiative and efficiency at least equal to those of any of our world competitors.

In a third of a century the production of copper in the United States, and to but a slightly less degree in the world, has grown from a very small to a very large industry. The growth during a generation has been many times greater than that of centuries before. Men are still living or have but recently died who have been active in developing some of the oldest copper districts of the United States. This wonderful growth in production has been due primarily to the extension of the electrical industry, and anyone who views the world as a whole must see that this industry is still capable of much larger extension. The demand for copper is sure to increase, and the vital question in the future is likely to be: Where can copper be obtained? rather than: How can copper be used? Few fields are more attractive to the geologist, the prospector, the miner, the metallurgist, or the capitalist than those in which copper is found,

won, and prepared for use in the advancement of civilization. The copper industry has all the elements needed to attract the best business and technical talent. The supply in the ground is fixed, but it is for us to determine how much of it shall be found and utilized, and those who may find new deposits or who may improve methods of mining or of metallurgy may well feel that they are doing work of far more value than is represented by the profits they may gain.

The American continent is securely in the leading position in the production of copper, but if that metal is to maintain its present relative importance among our mineral products its producers must continue to furnish it cheaply. If they attempt to exploit their rather close control of a metal so essential to the world's progress, or if they neglect to improve and economize in production to insure a reasonable cost, the spur of competition will be applied by the producers of aluminum or other substitutes, who thus will provide another supply of the material essential to the extension of the electrical industry.

If now that copper, like food, ships, and gasoline, has done its part in winning the war, there is a temporary over-production for our current needs, we should not be greatly disturbed, for there will probably be also an over-supply of labor, both that previously employed in manufacturing war materials and that released from military service. These resources will furnish the elements needed for further extending the electrification of our railroads, an extension strongly recommended by the Railroad Administration, and will thus serve a useful purpose in helping to carry us safely through the period of readjustment that must follow the war.

CHAPTER VII

LEAD AND ZINC

C. E. Siebenthal[1]

Notable difference in early war demand for lead and for zinc — Common association of the two metals in ores — Metallurgic treatment of the complex ores — Imports and domestic supply of lead — Restriction in use and allocation of lead supplies — Consumption of lead as affected by the war — Zinc supply in United States — Substitution of zinc pigments for lead pigments — Consumption of zinc as affected by the war — Use of sheet zinc instead of "galvanized" sheet iron — Use of zinc in making brass — War losses and salvage of brass — Foreign market for American zinc — Future of electrolytic spelter — By-product sulphuric acid in zinc smelting — Cadmium a substitute for tin in solders — General conclusion.

It is safe to say that the average American, after he had recovered somewhat from his astonishment that we could actually have a world war in this Twentieth Century and from his horror at the immense sacrifice of human life it was entailing, immediately fell to considering the practical demands and consequences of the war, and especially their effect upon his country and himself. He thought of the enormous supplies of war materials that would be required — of munitions — and what he had read of the Revolutionary War, the Civil War, and the Indian wars, as well as his own experience in hunting, led him to think that munitions meant powder and bullets, and therefore that one of the things most urgently needed would be a larger quantity of lead. His failure to comprehend the requirements of modern warfare is indicated by the fact that lead was

[1] United States Geological Survey.

one of the last metals to feel the stimulus of war prices; indeed, lead as a war bride seemed doomed to be left waiting at the church. Eventually, however, the war need for lead gave it a place in the family of war metals, and a small but continued excess of demand over production brought us to a positive shortage of lead and to strict Government supervision of its use.

With zinc, what a contrast! The bridal festivities began so early and the feast was so bounteous that it became necessary to go out into the highways and byways and invite the participation of the maimed and the halt. Every old dismantled and abandoned zinc smelter, including even the antiquated pioneer coal-fired plants of Kansas and Missouri, was eagerly rebuilt and set to work, and there was an orgy of zinc-smelter building such as the world had never seen, because most of the zinc smelters in the world except those in Germany and the United States stood along the Meuse River, in the line of the Teutonic advance through Belgium and northern France. Thus the burden of supplying the Allied and neutral nations with zinc for making munitions and for peaceful uses was thrown almost completely on the smelters of the United States, and the price of the metal therefore rose to unprecedented heights. After the orgy came the *Katzenjammer,* for overbuilding led to overproduction and low prices. But unprofitable returns resulted in so great a reduction in the output that zinc has recently brought fair prices again. Nevertheless, our smelting capacity is far beyond our normal needs, and unless there is an expansion in the domestic use of zinc or there develops a foreign peace market, we must have further curtailment.

Although lead and zinc are almost invariably associated closely in mineral deposits, they are as diverse

in their nature, uses, and metallurgy as they have been in their industrial career since the beginning of the war. In the United States there are but two large zinc deposits that contain no lead — one at Franklin Furnace, New Jersey, and another at Mascot, Tennessee, — and there is but one large area of lead deposits without zinc enough to pay for the metallurgic separation of the two metals — the district of disseminated lead ore in southeastern Missouri. Where the ores of these metals occur as sulphides, they are, as a rule, intimately mixed with each other, and in many places they are mixed with sulphides of copper, iron, and other metals. Before these complex ores — the "refractory ores" of the metallurgist — are smelted, the zinc minerals must be separated from the others because the metallurgic practice in smelting zinc is different from that used with the other metals. Zinc interferes so greatly with the reduction of the metals with which it is thus associated that a "fine" or "penalty" is placed by the smelter on ores and concentrates containing six per cent. or more of zinc, the limit depending on the character of the ore. It is interesting to note that the endeavor to avoid this penalty has led to some of the principal advances in metallurgy made in recent years. The great silver-lead-zinc ore body at Broken Hill, Australia, contains as much zinc as lead, but until recently lead and silver were the only metals recovered from it, and the zinc was got rid of by every possible means; it was separated and set aside in huge piles of zincky middlings or tailings, or at the lead smelters it was run into the slag waste, of which it constituted as much as 20 per cent. — three or four times the usual percentage of zinc contained in lead slags.

After many years of experimentation at Broken Hill

the flotation process was devised and perfected and is now generally used to recover the zinc sulphide both from the current output of tailings and from the piles that have accumulated for many years. In the flotation process metallic sulphides rise to the surface of the flotation tank and are drawn off for further separation or for reduction in the smelter while the waste rock sinks to the bottom. Thus what had been a handicap to metallurgic operations was changed to a useful product. In the years just before the war the zinc concentrates recovered at Broken Hill by this process yielded annually one-sixth of the world's production of spelter (metallic zinc cast in slabs as it comes from the smelter). The flotation process is now generally used in concentrating sulphide ores the world over. The accumulated zincky slags may also be made to yield their content of zinc in future through some process by which the zinc will be burned off and collected as zinc oxide.

Both lead and zinc can be burned off from their ores in oxidizing furnaces as vapor that can be passed through cloth bags which will strain out and catch the oxidized lead and zinc; these products are especially serviceable for use as pigments, and together with the "white lead" of commerce (lead carbonate), made by corroding metallic lead with acetic acid, form the base of the greater part of the paint now made. This possibility of burning ores in an oxidizing atmosphere has lately led to what promises to be a very great improvement in the metallurgy of complex refractory ores. Such ores are roasted and then burned, leaving copper and the precious metals in the form of residues from which they may be recovered as metal by the copper smelter. The oxidized "fumes," as the materials collected in the bag house are called, consist of zinc oxide and basic lead

sulphate; by treating these with sulphuric acid the zinc oxide is converted to zinc sulphate, from which metallic zinc is electrolytically precipated, the lead sulphate having been filtered off for treatment by the lead smelter.

The United States has always imported from Mexico and other countries large quantities of ores containing lead, has smelted them in bond, and has exported the pig lead. Owing to the decline in the imports of lead ore from Mexico in the years of disturbed conditions in that country which just preceded the Great War, the great burden of supplying the war demand for lead fell upon the producers in the United States. A gain of 25 per cent. in the output of lead from domestic mines was made in 1914, and another of 10 per cent. in 1916, but little or no gain was made in 1917 and 1918. Fortunately, however, the imports of lead from Mexico and other countries have recently increased. The influence of international politics in the metal industry is shown by the fact that as a result of increasingly stable conditions in Mexico she was able to send us almost as much lead in the first half of 1918 as we imported from all countries in the whole of 1917.

The supply of lead fell short of the demand in 1917, and for that reason the price of lead then reached its highest point. Although the stocks are probably less now than at any time during 1917, the price is but two-thirds what it was then; in fact, the industry has been recently carried on in a hand-to-mouth way, to which the price was no clue. The very evident war-time scarcity of lead caused the Government to supervise all sales and to allocate the metal to those industries whose need was most urgent as judged by their relation to the war. Conferences were held with the consumers of lead in order

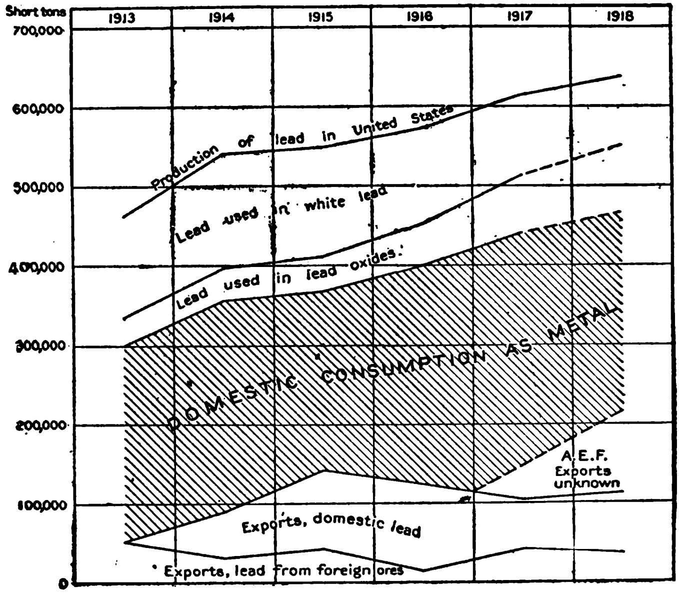


FIGURE 9. PRODUCTION, EXPORTS, AND CONSUMPTION OF LEAD BY THE UNITED STATES, 1913-1918

to devise substitutes and to make plans for curtailing consumption.

The accompanying diagram (Figure 9), shows graphically the steady rise in the output of lead by United States smelters since 1913. The lowest line represents the quantity of lead refined from foreign ore or bullion and exported, showing in a way the vicissitudes of political conditions in Mexico, from where most of our foreign lead comes. Domestic lead exports began in 1914 and were large throughout the war. The quantity of pig lead consumed in making white lead shows a marked decrease in the last two years because the increased cost of lead and of the other materials entering into paints so forced up the price as to restrict the demand. On

the other hand, the output of lead oxides, red lead and litharge, showed an increase due to their war uses — as ship and iron paints, rubber filler, etc. The shaded space represents the lead consumed in this country in metallic form. The lead sent overseas by the United States Government for its own use is not recorded so it can only be indicated.

A partial remedy for a scarcity of pig lead and a surplus of zinc is to be found in the substitution of zinc pigments for lead pigments. The lead pigments produced in 1916 contained about 175,000 tons of lead. For some of these pigments, including red lead, orange mineral, litharge, and sublimed blue lead, zinc pigments could not be substituted. The white-lead pigments alone, however, contained more than 110,000 tons of lead. The substitution of zinc pigments for a part of these lead pigments would relieve the stringency as to lead and make a market for more zinc. It is not desirable to try to substitute zinc for lead altogether, for a mixture of lead and zinc pigments with some inert base is preferable for many uses.

Although classed with the zinc pigments, leaded zinc oxide may contain as much as 25 per cent. of lead. The output of this pigment is rapidly increasing, and it could be still further increased by the wider adoption of a recent modification in zinc-smelting practice by which the residue from the retorts, which contains from three to seven per cent. of zinc and whatever lead was in the zinc concentrates charged into the retorts, which has been heretofore thrown away as waste, is burned to form leaded zinc oxide. By this means the percentage of zinc recovered from the ore is increased. However, as the content of zinc in the residue is low, especially when the smelting practice is good, only a small quantity of zinc

oxide is obtained in this way. It has been proposed to shorten the period of distillation in the retorts and thus leave enough zinc in the residue to permit an increased recovery of zinc oxide and make the operation profitable. It would seem feasible to smelt zinc concentrates containing considerable lead if this method of handling the residue were adopted, for the lead would be recovered as

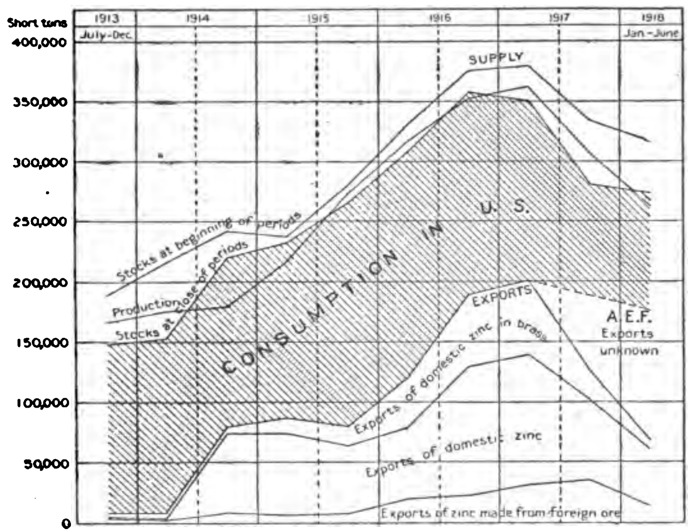


FIGURE 10. PRODUCTION, EXPORTS, AND CONSUMPTION OF ZINC BY THE UNITED STATES, 1913-1918, BY SIX-MONTHS PERIODS

leaded zinc oxide. This practice would save the zinc lost in making the clean (lead-free) zinc concentrate required by zinc smelters to enable them to make the high grade of spelter now in demand.

The war has shown that the United States is amply supplied with zinc, though our greatest deposits and those which have been our main reliance are, in comparison with some others, of very low grade. Our main

problem now is to produce zinc ore in competition with our nearest neighbors, of which Canada has the advantage of richer ore and Mexico the advantage of cheaper labor. Of the more than 2,500,000 tons of spelter which the United States has been called upon to furnish since the beginning of 1914, about 10 per cent. was made from foreign ores. During the same period large quantities of domestic zinc ores were converted into zinc pigment. Having speeded the capacity of our mines and smelters for producing zinc to a point much above our normal domestic needs, we must now find how to employ this surplus capacity after the war.

Figure 10 illustrates in a graphic way the remarkable expansion in the zinc industry caused by the war. Above the curve showing the production is a line representing the stocks at the beginning of each period. Stocks at the beginning plus production give the available supply. To get at consumption, however, the stocks at the close of each period must be deducted from the supply. There must also be deducted the exports, leaving the shaded area to represent the domestic consumption. A marked falling off in the supply and in the consumption has taken place since the last half of 1916, due probably, as suggested later, to the accumulation of stocks of used brass. Coincidently there has been a great drop in the price of zinc. The zinc sent to France by the United States Government for its own use is not recorded and hence can only be indicated. The exports of zinc made from foreign ores gradually increased from the beginning of the war until the first part of 1918. Exports of domestic spelter and sheets reached a large figure immediately after the war began, which was possible because there were domestic stocks of over 60,000 tons at the end of June, 1914. The exports of zinc in brass

and manufactures of brass also grew to large proportions, but these and the exports of zinc fell off sharply after the middle of 1917.

Before the war spelter was used chiefly for coating or "galvanizing" iron or steel sheets and articles to make them rust proof, and this use consumed nearly two-thirds of the entire output of spelter in this country. There was a surplus of zinc in the last year or two because at first the high price of spelter curtailed its consumption for galvanizing sheets and later, when spelter had become cheap enough, steel had become too scarce to be used for sheets. The galvanizing industry will of course resume operations as soon as the supply of steel will permit, but for some time after the war all the steel available will be absorbed in the rehabilitation of the Allied countries and in catching up with our own projects for building. For certain uses, however, galvanized sheets have been supplanted by sheet zinc. The current expansion of the capacity of the zinc rolling mills, amounting to about 50 per cent., is one of the outstanding features of the zinc industry, and an active propaganda to increase the consumption of sheet zinc under normal conditions is being waged. The use of sheet zinc instead of galvanized sheets in refrigerator linings was made compulsory by the War Industries Board, and this use alone, it is estimated, will absorb about 10,000 tons a year. Sheet zinc could also be advantageously substituted for galvanized sheets and sheet copper in roofing, guttering, and spouting, as well as in household utensils, except those used for cooking. It will doubtless be found that during the war Germany, with plenty of zinc but a scarcity of copper, worked out a great many ways in which zinc and its alloys, such as brass, can be substituted for copper or other metals, especially

in the electrical industry. Under the stress of war the substitutes "made in Germany" have probably led the world in number and volume, and the use of many such substitutes, introduced through necessity, will no doubt be continued from motives of economy or from sheer industrial inertia.

A large quantity of spelter is used also in making brass, which is generally two-thirds copper and one-third zinc. Brass was known to the ancients, but they made it by melting copper with zinc ores, not by melting together copper and spelter. In Europe the two metals were first directly alloyed about 1781, when a patent for the process was taken out in England. The extensive employment of brass in munitions recently caused that use of zinc to take precedence over all others.

The zinc in the brass that went into cartridge cases and other munitions was not lost when the shots were fired, for the empty cases were carefully collected, and such as were suitable for reloading were used again, perhaps several times, and the others were resmelted and worked over into new cases. The salvage of such brass averaged perhaps 75 per cent. An advancing army may recover 90 per cent. of its own brass cartridge cases and a large part of those of the enemy, but a retreating army saves few, if any. The losses of brass by the Allies in their retreat in the earlier part of 1918 must have caused a tremendous drain on their supply of brass, which may possibly be reflected in our future exports, although the salvage they made in their later advances may have partly offset this drain.

In the early years of the war the battle lines were constantly lengthening, so that greater supplies of munitions were needed, and the constantly increasing intensity of the action necessitated greater reserves of

munitions behind the individual sectors. These conditions caused the great demand for zinc which resulted in the boom prices in this country. In the last year or so, however, reserves of secondary or used brass accumulated in France which affected the exports from the United States and may go far toward wiping them out altogether for some time after the war. The exports of zinc and brass for the first half of 1918 were about one-half as great as those in the last half of 1917, which in turn showed a great reduction from those in the first half of 1917. Although it should not be forgotten that supplies carried on Government vessels for United States forces at the front are not counted as exports, yet the depressing effect of these reservoirs of secondary brass had made themselves felt in our markets even before our troops went across.

Since 1904 we have imported much Mexican and Canadian zinc ore, at times to the danger of our own zinc-mining industry, but we had exported very little spelter until the beginning of the war. Whether we can hold any part of our European trade in spelter after the war depends on several factors — whether the war will go far toward equalizing the cost of labor throughout the world; whether the Belgian zinc-smelting industry can be rehabilitated; whether England can build up a successful zinc-smelting industry under the labor conditions that exist both in England and in Australia, England's source of ore; and whether Europe will continue to demand high-grade metal. It is reported that a zinc smelter now under construction at Avonmouth, England, will be the largest in the world; it is certain that what was the world's largest smelter, one in Oklahoma, has recently been closed for dismantling. We may ask whether these events are prophetic. However,

the American smelter was closed on account of a failing and increasingly expensive gas supply and because it represented surplus capacity.

At the breaking out of the war it seemed that one favorable place for the expansion of the market for American zinc would be South America. But the war cut off the European banking connections of that continent, which found itself practically unable to purchase anything in the United States or elsewhere. Hence the market for our zinc products in South America can grow no more rapidly than the development there of American banking interests and the extension of American credit. The same is true of the other continents — Africa, Australia, and Asia — although the growing zinc-smelting capacity of Australia and Japan will doubtless meet most of the needs of Australia and Asia, and Africa will probably be supplied from Europe or may indeed have its own smelters. Zinc-smelting and electrolytic zinc plants are under construction in Spain, Italy, India, and Tasmania.

Until the breaking out of the war, as has been already stated, the spelter market of this country was the home market. Our high standard of wages made it impossible for us to compete in the world market with the zinc-producing countries in which labor is cheaper, though the tariff has enabled us to sell our spelter at home. Since the beginning of 1914, however, we have exported about 700,000 tons of spelter, not including zinc in brass, etc., of which 550,000 tons was made from domestic ores and 150,000 tons from foreign ores. The United States was at the termination of hostilities practically the sole source of zinc for the Allies and hence determined its price, but when we have keen world competition again. the high cost of producing domestic ores will place our

spelter at so great a disadvantage for export as to put it out of the running. We can overcome that disadvantage by smelting cheap foreign zinc ores in bond, just as we smelted foreign ores to get the 150,000 tons of spelter of foreign origin which was exported during the war. Probably the most advantageous place at which to build a smelter for this work would be at some point on the Virginia seaboard which would have direct connection with the West Virginia coal fields and to which sulphide ores from Mexico could be easily shipped by water. A fertilizer plant that used by-product sulphuric acid and Florida phosphate brought in by water might be operated in connection with the smelter. Such a smelter could also use Australian concentrates should they become available.

A question that might fittingly be asked here is: Will electrolytic spelter be able to compete with spelter produced in retort smelters when more normal conditions return? This question is of moment to many spelter producers, but its answer must depend on the conditions that may exist; it cannot be decisively answered at this time. For one thing, the "fashion" in spelter after the war can no more be predicted than the fashion in women's wear. Just as the munition workers and the laborers of most other classes got higher wages than ever before and indulged in luxuries they had never dreamed of a few years ago, so the brass consumer got unprecedented prices for his product and, for real or imagined advantage in working, demanded brass made from spelter of the highest grade. The question is: Will he forego this luxurious habit when the war is over?

The common grade of spelter, known as "prime western," may be raised to the higher grades by refin-

ing, either by redistillation or by electrolysis. Electrolytic spelter made directly from the ore is also of the higher grade, as is the spelter made from the zinc ores from the Franklin Furnace mines of New Jersey and the Mascot mines of east Tennessee, which are free from certain elements that are undesirable in spelter of the highest grade. The present cost of redistillation is about 2½ cents a pound. One plant that was engaged in refining prime western spelter by electrolysis quit operation when prime western spelter rose above nine cents a pound, and as high-grade spelter was selling for a maximum of 12 cents, it may be inferred that the cost of electrolytic refining is not much less than three cents a pound. The cost of making electrolytic spelter directly from the ore has not been fully disclosed, but it is higher than was expected and the recovery is not so large as was expected. The electrolytic zinc plant at Trail, British Columbia, was recently granted a Government bounty of two cents a pound on its product when ordinary spelter sells in the United States for less than eight cents a pound, and this grant seems to indicate that under the present conditions electrolytic zinc cannot profitably be made at that plant for less than about 10 cents a pound. Even under present conditions, however, high-grade spelter can be profitably made for considerably less than 10 cents a pound from the clean zinc ores in the New Jersey and Tennessee districts referred to above. The future of electrolytic zinc therefore depends on the quantity of high-grade metal needed in the market and the ability of the operators to improve the recovery and lower the cost.

One of the notable effects of the war on the zinc-smelting industry in the United States was a great increase in the output of sulphuric acid as a by-product

from the smelting of zinc sulphide ores. In 1914, 12 sulphuric-acid plants that were operated in connection with zinc smelters having 40,000 retorts produced nearly 300,000 tons of acid. At the end of 1917, 18 acid plants were operated in connection with zinc smelters having over 80,000 retorts, and these plants produced in that year over 900,000 tons of acid. Some acid plants have been enlarged since 1913, and many have "boosted" their capacity by burning brimstone in addition to utilizing the roaster gases from zinc smelters. The rapid expansion of the chemical industry in the United States since the beginning of the war assures a permanent and increasing market for sulphuric acid.[2] The high price of spelter in the early days of the war stimulated the building of a number of large smelters of more or less temporary construction and some smaller ones in the region of cheap natural gas that centers in eastern Oklahoma. The declining price of spelter and the waning supply and increasing cost of natural gas caused the closing of a number of these smelters in 1917 and 1918. With a narrowing margin of profit on spelter the large smelter of permanent construction, having all possible labor-saving mechanical equipment, built at its own coal mine, and saving by-product sulphuric acid, has a lower cost of upkeep and small amortization charges and therefore has a great advantage over the small natural-gas smelter, which must eventually be eliminated from the industry. The general recognition of this fact during the last few years is indicated by the increasing number and capacity of smelters built in the Illinois and Pittsburgh districts.

Secretary Lane has said that we should search every

[2] See Chapter IX for further discussion of sulphuric-acid production.

hill and dale of our country from boundary to boundary for deposits of the metals that we do not now produce or produce but sparingly. While we are searching our country we shall perhaps find it no less profitable to search our laboratories for substitutes for those metals, particularly to see if such substitutes cannot be fashioned from waste material. If we can make a by-product that has heretofore been useless take the place of a metal that is scarce, we shall be doing better than to discover a new deposit of that metal, for we shall be conserving a metal of which the world's total supply is small. Such work justifies the cost of research laboratories, the value of which, at our stage of industrial advancement, we have not yet fully learned. The utilization of by-products also conserves capital and labor, for without adding to the expense of mining it increases the returns derived from the ore.

Cadmium is an illustration very much in point. Starting in 1907 with an output of four or five tons, we produced in 1917 about 129 tons in the form of metal and sulphide. Cadmium is used in this country chiefly to color glass and as the main ingredient in the fusing tips of automatic sprinkler systems. The output in 1917 was more than the domestic needs, and considerable stocks were left on hand after the foreign demands were met. In France and Italy a fraction of one per cent. of cadmium is customarily added as a deoxidizer to the bronze used in telegraph and telephone wires, and we exported cadmium to those countries throughout the war. The present shortage and high price of tin have stimulated the search for a substitute for it, and solder made of lead, tin, and cadmium has been successfully used instead of the common lead-tin solder; it is cheaper and saves four-fifths of the tin formerly used. More-

over, experiments with tin-free lead-cadmium solder promise well, so that we may even do away with tin entirely in solder made for some uses. Patents have been taken out for such solders, which are already being used in Germany. Arbitrary conservation by enforced substitution, however, would be difficult, for the cadmium supply of the United States is not sufficient to permit the substitution of lead-cadmium solder for all lead-tin solder; moreover, such substitution would call for larger quantities of lead, since an equivalent weight of lead must replace the tin saved, and just at the time tin was so scarce, little if any lead could be spared. But at least there is no valid excuse for a metallurgic plant which, having several hundred tons of residues containing 80 per cent. of zinc and 10 per cent. of cadmium, treated them for the recovery of the zinc and threw away the cadmium.

Cadmium does not occur as an ore, but in minute quantities is an accessory constituent of almost all zinc ores, the ratio being about one of cadmium to 200 of zinc. Cadmium behaves metallurgically almost the same as zinc and hence constitutes a fraction of one per cent. of almost all spelter. It is recovered in Germany by fractional distillation in smelting zinc ores, but that process has not been used in this country. Almost all lead ores contain some zinc minerals, and the minute quantity of cadmium associated with the zinc accumulates in the bag-house "fumes" at the lead smelter until they are rich enough to treat for cadmium. The residues from the zinc purification vats used in electrolytic zinc reduction and in the manufacture of lithopone are also sources of cadmium. The known cadmium content of cadmium-bearing material recovered annually in the United States is about 600 tons, but much material that

may carry cadmium has not been tested for it, and possibly 1,000 tons a year may eventually be recovered. If this cadmium could replace 4,000 to 5,000 tons of the tin now used in solder, it would be an item of no small value in view of our lack of tin deposits and the possibility that the recent tin shortage may be repeated.

Although owing to the manner of their occurrence, it is not customary or possible to estimate the reserves of lead and zinc ores as closely as those of copper, it is well known that our supplies of lead ore are sufficient for our domestic needs, and that our zinc ores are more than ample for domestic needs and would permit large exports were they not prohibited by the higher costs of mining and smelting in the United States, the maintenance of which at that high level is made possible by the tariff. The privilege of smelting foreign ores in bond, however, allows the smelters of the United States to reduce Mexican and Canadian ores and ship the product abroad in competition with foreign products. Before the war practically all our exported lead and zinc was smelted in bond.

The original possession or the occupation early in the war of the principal metallurgical centers of Europe forced the Allies to draw upon us heavily for lead and zinc and their products. The United States was able to meet this demand adequately, but in so doing, built up its lead and zinc mining and smelting industries far beyond possible requirements in times of peace. The reaction overtook the zinc industry in 1917, and with the termination of hostilities struck the lead industry. Both will doubtless be in a slump of readjustment for some time to come, but they have this to their credit — they responded readily to the demand and they stood the strain.

CHAPTER VIII

MINOR METALS

Edson S. Bastin[1]

Manganese, an indispensable metal in steel making — The steel hardening metals — Nickel, the most widely used hardener for steel — Canada's dominance of the world's nickel production — Tungsten and its use in tool steels — Tungsten-steel tools have trebled the efficiency of the metal worker — Chromium, another steel hardening metal — Tin the basis of the world's canning industries — Our complete dependence on foreign tin supplies — Platinum and its rôle in acid making — The light metals aluminum and magnesium and their use in airplane and Zeppelin construction — Antimony, the lead-hardening metal — China, the cheapest source of antimony — Mercury.

This chapter deals with a group of metals the industrial importance of which is quite out of proportion to the small quantities of them consumed as compared with the consumption of iron and steel, copper, lead, or zinc. Among these metals is the steel-making metal, manganese. Nickel, tungsten, and chromium, which have been called steel "medicine" because they are added to steel in small amounts to remedy certain defects in steel, or, to put it positively, to give it hardness, toughness, or resistence to corrosion, are others. Tin, the basis of the canning industries, and aluminum, which is valuable for its lightness, will also be considered. Platinum, because of its use in the manufacture of strong sulphuric acid, is essential to a host of chemical industries, and antimony, mercury, and magnesium have special and valuable functions to perform in the intricate mechanism of modern industry.

[1] United States Geological Survey.

In modern steel making manganese is as necessary as iron itself; one eminent metallurgist has said that steel is not steel unless it contains manganese. Although on the average only seven pounds of manganese are added to each 1,000 pounds of steel, this small amount is as essential as yeast in bread making and its effects are equally out of proportion to the meagre amounts used. Its exact chemical effect on the steel is still uncertain and indeed varies with the steel-making process, but its physical effect is a marked improvement in the quality of the product.

Manganese metal is expensive to produce as compared with alloys of iron and manganese. In steel making, therefore, manganese is added in the form of alloys, ferro-manganese and spiegeleisen. Ferro-manganese contains 70 to 80 per cent. of manganese and is made from high-grade manganese ores; spiegeleisen contains 20 to 32 per cent. of manganese and is made from low-grade manganese ores. In general, ferro-manganese is used in making low-carbon steels by the open-hearth process, whereas the cheaper alloy, spiegeleisen, is used in making steels higher in carbon by the Bessemer process, the resulting steels being adapted to somewhat different uses.

In addition to its use in improving the qualities of ordinary grades of steel, ferro-manganese is used in the manufacture of steel still richer in manganese, known as "manganese steel," which is adapted for use in the jaws of crushing machinery where hardness combined with great toughness is required. Higher grades of manganese ores find a minor use in the dry batteries that ring our door bells and small batteries for pilot flash lights, about 25,000 gross tons being consumed annually in the United States for such purposes; manganese ores

also find a limited use in glass making. Fully 96 per cent. of the world's manganese ore production is consumed, however, in the manufacture of steel-making alloys.

The position that manganese occupies as the premier steel alloy metal is the result of its relatively abundant occurrence in nature and also of the fact that both ferromanganese and spiegeleisen can be made in the ordinary blast furnace, whereas nearly all other substances that have similar effects upon steel and might be regarded as competitors can only be manufactured at greater expense in the electric furnace. Furthermore, most manganese ores occur within 100 feet of the surface where they can be cheaply mined.

Russia, India, and Brazil have been the world's principal sources of supply for manganese ores, and each of these countries consumes only negligible amounts, most of the output going to the great steel-producing countries, the United States, Great Britain, France, and Germany. Prior to the Great War the Indian ore was used mainly by British plants, Brazilian ores came mainly to the United States, and the Russian ore went mainly to Germany, although small amounts were consumed in Russia.

The war produced great changes in the manganese situation throughout the world. The sudden outbreak of hostilities in Europe in 1914 by closing the Dardanelles cut off most of the world from the Russian supplies, the largest of which are near the east end of the Black Sea. This event, coincident with a great increase in demand for steel for munitions and for shipbuilding, precipitated a world shortage of manganese ores and led to unusually heavy demands upon India and Brazil, to active prospecting for new deposits, and to the de-

velopment of known but unworked deposits in many parts of the world. During the war new manganese districts were discovered and brought to a producing stage on the Gold Coast of South Africa, in Costa Rica, and in Java, the deposits in the latter country being large and having considerable possibilities for the future. The Indian output went mainly to England and to France; the enlarged Brazilian output came mainly to the United States, but the United States supplemented her imports by increased production on a scale that was a revelation even to those most familiar with her latent mineral resources.

Prior to the war the United States was dependent upon foreign sources for 99 per cent. of her manganese supplies. After the outbreak of the war the increased needs of France and England for Indian and Brazilian manganese ores and later our own desire to avoid long ocean freight hauls in order to release ships for transport of troops made it imperative to reduce by every means our dependence upon foreign supplies. America's response was to largely wipe out in less than two years her dependence upon foreign supplies. Domestic production of high-grade ore (over 35 per cent. manganese) increased from about 14,000 long tons in 1913 to the remarkable figure of 294,000 tons in 1918. The production of low-grade ores (10 to 35 per cent. manganese) increased from 60,000 long tons in 1913 to 800,000 tons in 1918. Because of this development it was possible during the last year of the war to curtail the imports from Brazil to 345,000 long tons, a decrease of 167,000 long tons from 1917, and had the war continued the United States could in 1919 have further curtailed her imports. Exports of manganese ores and alloys were negligible except small shipments to Canada.

The occurrence of most manganese ores within 100 feet of the surface, where they are easily discovered and may be cheaply and expeditiously mined, has been one cause of the rapid expansion of domestic production of these ores during the war. The cause of this shallow distribution is that the air and water at the earth's surface are necessary reagents in nature's process of making these ores. In the process of weathering they act upon veins, beds, or other bodies rich in manganese, carbonates, or similar minerals, and convert them to dark brown to black manganese oxides; by the dissolving and carrying away during this process of many other constituents the manganese content of the lower-grade minerals is increased.

In a few places the light colored, usually pink, manganese minerals from far below the surface are worked as sources of ferro-manganese or spiegeleisen. The zinc ores of Franklin Furnace, New Jersey, which are iron and manganese-bearing zinc oxides, yield spiegeleisen as a by-product in the manufacture of zinc oxide. An interesting war-time development of the manganese industry was the erection of a plant by the Anaconda Copper Company at Great Falls, Montana, for producing ferro-manganese from pink iron-manganese carbonate, an abundant and hitherto unused mineral in some of the mineral veins of the Butte district. Although the plant was completed in September, 1918, the collapse of prices accompanying the signing of the armistice and the termination of hostilities came before any of the product was marketed and it has not since been operated.

The many war-time changes in the manganese industry presage great but more leisurely changes in the peaceful years to come. As long as present practices in

steel making persist, manganese will continue to enter largely into world trade, for none of the great steel-producing countries is now self-sufficient. If uninterrupted world commerce were permanently assured, manganese should cause us no anxiety, for the world's known supplies are sufficient to meet the needs of her steel industries for a long term of years, but the dangers of the situation lie in the possibilities of war. For France and England, with negligible reserves of manganese ores, these dangers are very real; for Germany and the United States, possessing large reserves of low-grade manganese ores, they are grave but perhaps not insuperable. Experience in steel making has shown that the quality of the steel depends not only upon the quantity of manganese added, but also upon whether it is added as ore or as alloy, and whether it is added early or late in the steel-making process. Recent experiments warrant the hope that steel makers may yet learn to apply low-grade ores or spiegeleisen in such a way that as good steels will be produced as with high-grade ores and ferro-manganese. If this time ever comes, both the United States and Germany will become for a brief period at least independent in regard to manganese supplies, for both have immense reserves of low-grade ores.

Although known even to the ancients, nickel was not widely used until after great deposits of nickel ore had been discovered on the island of New Caledonia and at Sudbury, Canada. These large supplies, which are available at moderate cost, stimulated the discovery of new uses for the metal, supply in this case truly creating demand.

Before the New Caledonian deposits were opened up

in 1875, the world's output of nickel, amounting to only a few hundred tons annually, was used mainly for plating expensive articles of iron and copper to prevent them from rusting, but after the great deposits in New Caledonia, and later those in Canada, were opened, nickel was applied to a host of valuable uses. Chief among these uses is its employment in the manufacture of steel, which consumed probably 75 per cent. of the nickel produced during the war and 60 per cent. of the normal output in times of peace. Nickel is the most widely used alloy of steel, and it is employed in making products so essential as structural steel, railroad rails, cannon, shells, and armorplate for battleships. The nickel content of these products ranges from 1.5 to 4.5 per cent. The particular virtue of nickel steel lies in its hardness and elasticity; tungsten and other minor metals can give even greater hardness but not the elasticity that nickel imparts. The successful use of nickel steel in shafts of steamships is excellent evidence of its ability to withstand frequent and severe strains. It is interesting to note that certain iron ores mined in Cuba contain in their natural state enough nickel to improve greatly the quality of the steel made from them.

Nickel also forms useful partnerships with many metals other than steel. The well known alloy sometimes called German silver, used extensively for making draftsmen's instruments and for other purposes, is an alloy of nickel, copper, and zinc, and our familiar nickel coins have a somewhat similar composition. Nickel coins are not a modern device, for coins struck in Persia more than two centuries before Christ contain nickel and copper in proportions similar to those used in coins today. Large quantities of nickel are used in nickel plating, and bicycle and automobile factories are among

the largest consumers of the metal, which is used not only in plating parts of the machines but in the nickel steel that forms the framework.

As each year brings new uses for nickel, and particularly for nickel steel, it is well to take stock of our future supplies. In 1916, 86 per cent. of the world's supply of nickel came from the province of Ontario, in Canada, nine per cent. from the French island of New Caledonia, two per cent. from Norway, two per cent. from the United States, and one per cent. from all other countries. Thus, France and Great Britain practically control the world's supplies, but the United States has held an important place in the nickel industry not only because of her large consumption of the metal but also because the entire Canadian output has been refined in the United States at the works of the International Nickel Company, at Bayonne, New Jersey. Our importance in the nickel industry will, however, be somewhat diminished in the near future, when a plant now being erected in Canada, with a capacity sufficient to handle about half the Canadian production, is put into operation.

The small quantity of nickel produced in the United States comes not from nickel mines but from the electrolytic refining of copper that contains only minute amounts of nickel. Scattered small mines in this country have from time to time produced a little nickel ore, but the output from these mines is negligible; nor is it likely that any large deposit of nickel ore will ever be found in this country. The United States is and probably always will be mainly dependent upon Canada for its supply of nickel, and in view of this fact it is consoling to know that the Canadian reserves contain probably over 150,000,000 tons of ore, or sufficient, at the

present rate of production, to supply the demand for a hundred years.

The reserves of nickel ore in New Caledonia of a grade workable under present conditions are very large, but immensely larger supplies of ore of somewhat lower grade are also available there. If coke can be successfully made from coals that are found in New Caledonia, these lower-grade reserves can be profitably utilized. The New Caledonian deposits are nearly 6,000 miles away from the United States, and the nickel from this source will probably become of decreasing importance to our own country from year to year, so that its great part in the world's economy will be to supply the growing needs of Asia.

From the earliest times man's tools have formed a useful measure of his progress in civilization. Passing from the age of stone to the age of bronze, the age of iron, and the age of steel, mankind may now be said to have reached the age of tungsten steel, for the superiority of tools made of tungsten steel over those made of ordinary steel has trebled or quadrupled the efficiency of the metal worker. The ores of tungsten are among the rarer minerals, and the principal producing districts are widely scattered over the globe, the United States, Burma, the Shan States (Indo-China), Bolivia, and Portugal being the largest producing countries, and Japan, Chosen (Korea), Peru, the Malay States, Spain, and Siam smaller producers. The ores from all these countries are brought to the few great steel-producing centers in the United States, Great Britain, and France, and before the war they were sent to Germany and Austria.

The world's entire output of tungsten in 1917 (reck-

oned, according to the usual practice, as concentrates containing 60 per cent. of tungstic oxide) amounted to only about 25,000 short tons, so that its transportation even from distant parts of the world is not a serious shipping problem, but the importance of this metal is altogether out of proportion to its relatively meager tonnage. At the steel-making centers the ores and concentrates are treated in electric furnaces to produce metallic tungsten or, more commonly, to produce an alloy of iron and tungsten known as ferro-tungsten. By adding one pound of tungsten to four or five pounds of steel the quality of the steel is so greatly changed that a metal-working lathe or plane equipped with cutting tools made of it can be operated four or five times as fast as if its cutting tools were made of carbon steel. To state the effect in more technical terms, the introduction of tungsten into steel raises the temperature at which the steel loses its temper when it is heated by the friction produced by cutting other metals. When it is remembered that a tool weighing a few pounds may be used to shape a cannon weighing tons, the utility of tungsten in the metal-working industries becomes apparent.

So well aware was Germany of the value of this metal in warfare that for several years before the war she imported abnormally large quantities in her preparation for the struggle; in 1916 she carried from the United States in the submarine *Deutschland* 55,000 pounds of metallic tungsten, and afterwards she lost no opportunity to smuggle tungsten from neutral countries.

The United States is the only great steel-producing country that is fortunate enough to possess large domestic deposits of tungsten ores, but even these deposits did not prove adequate to meet the domestic needs, which

increased from 3,100 short tons (of 60 per cent. concentrates) in 1913 to over 4,100 short tons in 1917. Our 1918 needs were estimated at about 12,000 short tons, and as the domestic production in 1917 was only about one-third of this amount, it was necessary to import large quantities from abroad. The competition for tungsten among the Allies during the war was so severe and the problem of its equitable distribution was so complicated and vexatious that an inter-Allied commission similar to that which handled the world's tin supply was formed to handle the supply of tungsten.

Although 90 per cent. of the world's output of tungsten goes into steel, a part of it is employed in another very important use — the manufacture of tungsten filaments for electric-light bulbs. With one-third of the current required by the old carbon filament, a tungsten filament gives a light of the same brightness and of better quality. Thus tungsten has earned distinction not only for saving man power, but for saving fuel in light making.

Chromium is another metal that finds its main use in steel making. Prior to our entrance into the Great War, our supplies of chromite, the principal ore of chromium, were imported mainly from distant points, from Rhodesia or from New Caledonia, the latter famous also for its nickel mines; but these long ocean hauls, which consumed about four months in the round trip, were too costly of ships except when metallic ores were needed for ballast, and under the stimulus of a war embargo on imports from these distant deposits, the domestic deposits rapidly increased their production. At the same time certain unessential uses of chromite, such as its use in lining furnaces, were reduced or aban-

doned. As a result, at the end of the war the United States is able to be self-sufficient in this mineral, though imports from recently discovered deposits in Brazil and Cuba, as well as in Canada, are still contributing to our supplies.

Most of the domestic chromite is mined in California, though small quantities are mined in Oregon, Washington, and Alaska. Our own deposits contributed generously in our emergency but they are small compared with the foreign deposits. Their development at the wartime rate, if long continued after the war, will squarely raise the question of the wisdom of exhausting a resource that may some day be sorely needed, perhaps in the next war. Who is wise enough, however, to say that if the world suffers another great war, some other metal may not have replaced chromium in all its war uses?

Many compounds of chromium are highly colored substances, green, yellow, or orange, and for this reason they are much used in paints and in dyeing. One of the less brilliant chrome dyes is used in coloring most khaki clothes, and so gives color to the modern armies as butternut dyes gave color to some of the Confederate regiments in the Civil War. Certain chromium compounds are also among the best substances known for tanning leather, especially leather to be used for outing shoes and boots.

The tin can is the world's most useful food container. It permits us to eat in February the fruits that ripened in August, to enjoy Hawaiian pineapples in New York, and to have sea food on our table in the middle of the nitrate desert of Chile. The "tin" can is, of course, mainly iron, but it is the resistence of its tin coating to rust and to the acids contained in foods that requires

its use in food packing. The tin is spread surprisingly thin on the "tin plate" from which cans are made, two pounds of tin sufficing to cover as much as 450 square feet of sheet iron.

Never before in the world's history has it been necessary to ship canned foods in quantities so large and for distances so long as during the Great War, when rations for the armies in Europe were packed in the United States, in Japan, or even in Australia or New Zealand. The world's output of tin, which in 1917 was between 135,000 and 140,000 short tons, was not adequate for these tremendous tasks, and tin became the cause of as much governmental anxiety and regulation as any other metal except platinum. So serious was the shortage of tin that the larger part of the world's output was distributed by an inter-Allied commission, and in most of the belligerent countries energetic campaigns to conserve tin were carried on and methods of economizing its use employed. If we examined the can in which our favorite brand of coffee was packed, we were more than likely to find that though the top was made of tin plate, as in former years, the bottom was black sheet iron and the sides were cardboard. Our chewing gum had an extra wrapper of oiled paper between the gum and the "tin" foil, which meant that the foil was no longer tin foil, but lead foil, the oiled paper being used to protect the gum chewer from lead poisoning. Even the children did their share towards conservation by saving tin foil. The shortage of tin in the Central Empires was so great that early in the war pewter services in Austrian churches and similar utensils in homes and museums, however fine examples of artistic craftsmanship they may have been, were melted to furnish material for making the more humble tin can.

The utility of tin does not stop with its use in the packing of foods. The five-gallon "tin" oil container has been spread by Standard Oil salesmanship to all the frontiers of civilization, where it is a useful makeshift in filling many humble needs. It is the common substitute for the water bucket, and in the barren wastes of the nitrate deserts of Chile, I have seen huts built of dirt-filled oil cans in lieu of bricks. Tin is a component of solder and of the collapsible tubes in which toilet creams are put up; its oxides, white and infusible, are used in making white enamel for metal surfaces; and, to present a sharp contrast to these utilitarian uses, it may be noted that the chloride of tin is employed to give an aristocratic rustle to my lady's silk gown. About 35 per cent. of the tin consumed in the United States is used in tin plate, 20 per cent. in solder, and 13 per cent. in bearing metals; the remaining 32 per cent. is used in numerous and various other ways.

In 1917 Asia furnished over 60 per cent. of the world's tin, the Malay Archipelago being the principal productive region. About 10 per cent. came from Bolivia, and the remainder from Australia, Nigeria, Cornwall (England), and the Union of South Africa. The United States consumes about 70 per cent. of the world's supply, but it produces none except insignificant amounts from gravels in Alaska and from a few small veins in the United States proper. In all, our country produced in 1917 only one-eighth of one per cent. of the tin it required, and there is no reasonable prospect that it will ever supply more than a very small part of what it needs. In view of our nearly complete dependence upon foreign sources it is interesting to contemplate what we should do if we were completely cut off from these sources, and here we may obtain some useful hints from

Germany's plight during the Great War, for Germany and Austria produce probably not over 50 tons of tin annually. As Germany did not need to transport food for distances as long as those traversed by supplies for the Allied armies, she sent much food in cardboard containers and shipped dried rather than canned food. For some uses she substituted zinc plating or galvanizing for tin plating and used aluminum receptacles instead of those made of tin plate. Zinc foil largely supplanted tin foil. The use of solder containing tin was obviated by increased use of riveting or of folding and crimping, and for some uses a new solder consisting of an alloy of lead and cadmium was largely employed.

In view of the wide distribution of tin over the world it is hardly likely that we in the United States shall ever be compelled to resort to such an extent to similar expedients, but if we should be so constrained, we can easily employ at least one of these methods of conserving tin — that of substituting aluminum for it, for the United States produces over half of the aluminum now used in the world.

The aborigines of Ecuador set the fashion for the ladies of today by wearing ornaments of platinum at least 2,000 years ago, but the metal seems not to have become generally known in the world until a comparatively recent time. The earliest platinum that reached Europe came from the Choco district in Colombia. This "noblest" of the metals began its modern career very ignobly a century and a half ago as a tool of Spanish and South American counterfeiters and swindlers, who struck off counterfeit Spanish doubloons of platinum and gilded them, and also paid some of their debts in Europe with yellow ingots of "gold" so heavily alloyed

with platinum that the little gold they contained could not be recovered because of the imperfect knowledge of refining in those days.

In 1828 Russia began to make platinum coins and thus gave the metal a respectable and assured position in society; from that time to the present the usefulness of platinum has constantly increased, and its value has risen from one-third to more than five times that of gold. The Russian platinum coins were long ago remelted for electrical and chemical uses, and the metal is no longer coined, but it has attained a remarkably important place in the chemical and electrical industries.

Probably not more than 10,000,000 ounces, or 425 short tons, of metallic platinum is in use in the world today, an amount equivalent to the world's production of pig iron for about three minutes, but the industrial value of this small quantity can hardly be estimated. Difficult to refine and resistant to the action of most of the strongest chemicals, platinum is nevertheless a source of unusual and little understood power, for it is capable of stimulating chemical activity in other substances. It may properly be called the "magic touchstone" of chemical industry. When the chemist brings air and sulphur dioxide into contact in the presence of steam, those gases mingle, but no chemical action takes place between them. If, however, a small mass of spongy platinum is in contact with the mingled gases, they energetically attack each other, forming sulphur trioxide, which, when combined with water, yields sulphuric acid. The platinum itself, though it causes this transformation, is apparently unchanged, and even after long use it shows practically no loss of weight. The strange so-called catalytic power of platinum on mixtures of these two gases forms the basis of the most effective process of

making strong sulphuric acid, the most essential substance in our chemical industries, including the manufacture of explosives. The same energizing power of platinum is also the basis of the latest and most promising method of manufacturing nitric acid from ammonia.

Although these chemical uses of platinum are the most valuable, and although they require large amounts of the metal and because of their increasing employment may eventually consume a considerable part of the world's supply of platinum, there are other uses that now absorb even larger amounts. Platinum crucibles and dishes have for many years been regarded as an essential part of the equipment of every chemical laboratory that is engaged in careful work, because of the resistance of the metal to high temperatures and to most chemical reagents. Nothing has yet been discovered that is quite equal to it for all its laboratory uses, though certain alloys of gold and palladium have recently proved to be suitable for many of them. Platinum has been extensively used in dentistry in bridges for attaching artificial teeth and as foil for making molds in which to bake porcelain fillings for cavities in teeth, but gold-platinum alloys are now being successfully substituted for it. The extreme ductility of platinum, its susceptibility of being drawn out into fine wire, is of much importance in many of its uses. The degree of this susceptibility is illustrated by the statement that a single troy ounce of the metal will make a wire 1,800 miles long and so fine as to be invisible to the unaided eye.

In certain electrical apparatus, such as telegraph instruments and magnetos, where the current must be frequently interrupted, it is necessary to have at the points of contact — of "make" and "break" — some moderately hard metal that will always present a clean and un-

corroded surface. Alloys of platinum and iridium form the best known material for this use, but a number of substitutes have been discovered, among them tungsten and molybdenum.

The use of platinum in jewelry is well known. During the Great War the making of platinum jewelry was largely abandoned, but only trifling amounts of platinum jewelry were remelted to enlist the metal in the service of war industries. Platinum lends itself especially to the making of charmingly delicate scrollwork mountings for diamonds and other stones, and the remelting of such objects to supply war necessities is so ruthless a sacrifice of human labor as to suggest the wisdom of accumulating in the Treasury stocks of platinum sufficient to at least partially meet a war emergency. At the present time about half a million ounces of platinum are in use in jewelry.

For the scarcity of platinum in comparison with other metals there are excellent reasons which merit brief consideration. Russia and Colombia have a natural monopoly of the platinum-mining industry of the world. The metal occurs elsewhere, even in the United States, but in amounts so small as to influence the world's supply but little. In 1913 Russia produced 93 per cent. of the world's output, Colombia six per cent., and all other countries a little less than one per cent. This restricted distribution of platinum is the result of an unusual combination of geologic conditions: (1) platinum usually occurs as a component of certain peculiar and not very abundant kinds of rock that have been solidified from a molten state; (2) the decay of these rocks and the washing away of their less valuable constituents by stream action extending through long periods is necessary to concentrate the platinum into work-

able deposits. In the great Russian platinum district large areas are occupied by a dark rock known as gabbro. Within these areas there are scattered smaller areas of another dark rock composed mainly of one mineral, olivine. Within this rock, in turn, there are small lenses or irregular patches that are rich in the mineral chromite. With this chromite platinum is in places associated. The location of the platinum in the "bull's eyes" of this concentric series of rocks is very significant, for it means that in the solidification of the rocks from a molten condition the platinum, which was originally distributed throughout the great mass, became segregated by one of Nature's processes of concentration in the small lenses of chromite, which were the last parts of the mass to solidify. But even this concentration was not sufficient to make workable deposits, and Nature had to continue the process through another agency, streams, which washed the platinum from the lenses and concentrated it in the bottom layers of river gravels. Where this washing has been repeated two or three times, deposits rich enough to meet man's exacting demands have been formed in a layer at the bottom of the gravels ranging in thickness from a few inches to a few feet. In view of this long and complicated process of natural concentration the rarity of platinum is hardly to be wondered at.

The United States has been, and probably always will be, mainly dependent upon foreign countries for its supply of platinum. The collapse of the Russian platinum industry incidental to the Russian revolution was a serious blow to the Allies and was the chief cause of the world's war shortage of that metal. The rehabilitation of the Russian industry under political and commercial control that will secure to all nations after the

war a fair share of the output is part of the problem of Russian reconstruction. We shall probably require a share of the Russian output, but our imports from Colombia have recently increased, and because of our proximity to this sister republic and our increasing commerce with her, we shall probably in the future depend more and more upon Colombian platinum. The annual output of platinum in the United States amounts only to about 4,000 ounces, most of which is obtained in the electrolytic refining of copper and nickel matte and gold bullion and in working gold gravels in California, Oregon, and Alaska. Two mines, one in Wyoming and the other in Nevada, yield small amounts of platinum from vein deposits.

The common use of aluminum is so distinctly peculiar to the present generation that most of us can readily recall when it was a novelty. The marvelous growth in its use is illustrated by the fact that in 1883 only 80 pounds was produced in the United States, whereas in 1914, about 30 years later, about 80 million pounds was produced. The metal was not utilized earlier because it does not occur in nature in metallic form and because its ores, though abundant, yield their metal content very reluctantly. Its large modern use has been made possible through the development of powerful hydroelectric plants.

Aluminum was first produced in 1827 by a chemical process, and for 30 years thereafter the chemical method of extracting it was the only one known, one of two powerful agents, metallic potassium and metallic sodium, being invoked to reduce natural or artificial aluminum salts to the metal. Modern developments of electric power have removed the aluminum industry from the

field of pure chemistry to that of electrochemistry. In 1885 aluminum was first produced in England and the United States by this method, not as the pure metal, however, but as an alloy of aluminum and copper known as aluminum bronze, the copper being indispensable to the process used. From that time to the present the uses of the metal have multiplied with wonderful rapidity, and its price per pound has declined from $5 in 1888 to $1 in 1891 and 20 cents in 1914. With the outbreak of the war the price leaped to 60 cents, and it was later fixed by the Government at 33 cents.

The conquest of the air has been due in no small measure to the availability of aluminum for building airplanes and dirigible balloons, and in such uses it is destined to play an increasingly important part. It is popularly regarded as the lightest of the metals, but magnesium is nearly 40 per cent. lighter and is frequently alloyed with it for making parts of airplanes.

Aluminum is of military value for use not only in the frames of airplanes but in their engines, as well as in automobile engines, in cooking kits and soldiers' helmets, and in numerous other articles. One of the principal ingredients of ammonal, an explosive used in large quantities in the Great War, is aluminum dust. Cables of aluminum with cores of steel wire have been substituted for the much heavier copper cables used for transmitting power, even in countries where copper is plentiful, and in Germany during the war aluminum almost entirely replaced copper for this use.

The aluminum industry of America is controlled by a single company, the Aluminum Company of America, which operates four electrolytic plants at points where abundant water power is available — two in New York, one in Tennessee, and one in North Carolina. The pro-

duction of aluminum in this country since the war began has nearly doubled and exceeds the combined production of all other aluminum-producing countries — England, France, Switzerland, Norway, and Austria.

The raw material from which aluminum is obtained is bauxite, a hydrous oxide of aluminum, of which the United States has resources so large that it is independent of the rest of the world as to this metal, although before the war some bauxite was imported from France, and these imports will probably be resumed. The domestic production of bauxite, principally from deposits in Arkansas, Tennessee, and Georgia, has increased from a little over 700 long tons in 1889 to 425,000 long tons in 1916. During the war the aluminum required by the Central Powers was supplied by plants in Austria and Switzerland, which perfected a method of using low-grade bauxite and high-grade clays as their raw material.

The aluminum industry of the world is to-day dependent in an interesting way on a supply of cryolite, a natural aluminum fluoride that is mined only in Greenland and that is essential in small amounts in the bath from which aluminum is deposited. These deposits are the property of Denmark, and from them both groups of belligerents in the Great War received supplies. It has been demonstrated, however, that artificial cryolite can be substituted for the natural mineral, and any nation that possesses enough water power and high-grade clays will probably be self-sufficient in its supply of aluminum.

Magnesium is another metal which, like aluminum, can be obtained from its compounds only by the aid of such powerful chemicals as metallic sodium or by the

use of a powerful electric current. It is a giver both of light and of lightness. In warfare it is used in aerial bombs and rockets for lighting the battlefields at night, and it is also put, in powdered form, into shrapnel shells so that the gunners may see where the shells are bursting. Thus it is a veritable "cloud by day and pillar of fire by night" on the field of battle. Its use in flash-light photography is familiar enough to all of us. Because it is both lighter and stronger than aluminum, with which it is alloyed, it has become an essential element in airplanes and dirigible balloons.

The manufacture of magnesium on a large scale is the youngest of our metal industries. From its commercial inception in the United States in 1915 to the present its development has been rapid, the production in 1917 reaching nearly 116,000 pounds, with every indication of more than twice this output in 1918. This wonderful development, a part of America's answer to the demands of war, has probably laid the foundation for a permanent industry, for the manufacture of a metal capable of adding both lightness and strength to aluminum is not likely to be abandoned. Its use in battle planes may be expected to be perpetuated in the construction of airplanes for peaceful purposes, and the development of many new utilizations is probable.

The producing capacity of the plants in the United States is limited only by the market demands and the availability of electric power and coal; the principal raw material, magnesium chloride, is cheap and abundant, being saved as a by-product in the manufacture of common salt at many places in the United States. Some magnesium is also made from magnèsite. Our resources of both common salt and magnesite are enormous.

not be exploited if expensive plants were required. (2) Most mercury deposits thus far worked have not extended to great depths, so that the prospect for long continued development to considerable depths of the deposits worked by the older mines is not so favorable as those offered by some other kinds of mining.

CHAPTER IX

MINERALS IN THE CHEMICAL INDUSTRIES

STEPHEN R. CAPPS[1]

The chemical laboratory essential to modern industry — Mineral raw materials of three types — Sulphuric acid and its raw materials — Increased output of acid required under war conditions — American sulphur — By-product acid — Pyrite and sulphur reserves — The dye-making industry — By-product coke making — Mineral fertilizers — American potash — Growing importance of the new industry — Increased demand for nitrates — America's leadership in phosphate rock — Lessons in thrift.

The chemical laboratory is now a necessary part of every steel plant, fertilizer factory, and dye works. Manufacturers in every field, seeking to better the quality of their products or to reduce costs, have found the services of the chemical engineer indispensable. Old rule-of-thumb methods have been scrutinized in the light afforded by scientific experimentation, and great improvements have been made in fundamental processes, especially in the utilization of by-products that had been considered waste and discarded. All industries that convert raw materials into finished products thus fall within the field of the chemist, but this review will consider only chemical industries in which the chief manufactured article represents the combination of raw materials of mineral origin, and even of these industries only a few of the most conspicuous can be mentioned.

The minerals employed by the industrial chemist are used either in the raw state in which they are taken from the earth, as refined products from which un-

[1] United States Geological Survey.

desirable impurities have been removed, or as secondary products. Thus, common salt, a mineral widely distributed in nature, is a basic material in the manufacture of alkalies. The Chilean nitrates, which are of great value in the manufacture of explosives, are mined as a natural product, but they require refining to remove objectionable impurities. Sulphuric acid is of the third type, and may be termed a secondary product, as it is manufactured from sulphur or sulphur-bearing minerals. The coal-tar derivatives, obtained by the distillation of coal, may also be considered secondary products. All three types, however, are directly dependent upon abundant natural supplies of minerals.

Sulphuric acid is more than any other one material the basis of the industrial chemistry of today. Someone has said that the degree of advancement of the civilization of a nation may be measured by the quantity of soap it uses. It is equally true that the industrial advancement of a people is in direct proportion to the quantity of sulphuric acid they use. This acid has won a dominant place in the chemical industry because it is cheap, contains tremendous chemical energy, and has low volatility. In most reactions in which sulphuric acid is used, a large amount of heat is generated, and this heat is useful both in promoting the desired reaction and in other ways. Furthermore, strange as it may seem, concentrated sulphuric acid may be stored or transported safely in ordinary iron tanks, although diluted sulphuric acid is highly corrosive to all but a few of the more expensive metals, such as gold and platinum.

The principal raw materials required for the manufacture of sulphuric acid are the metallic sulphides or native sulphur. By simple processes these materials are burned to produce sulphur dioxide gas, which may be

made to take additional oxygen from the air and can then be absorbed in water to produce sulphuric acid of any concentration required. The cheap and abundant production of sulphuric acid, therefore, must depend largely upon a sufficient supply of low-priced sulphur or sulphide at a point whence it can be shipped readily and cheaply to the manufacturing centers. It is more economical to ship sulphides or sulphur than to ship the manufactured acid, both because solid ore is more easily handled than liquid acid and may be shipped in ordinary freight cars, and because the large quantity of water added in the manufacture of the acid makes it weigh more than either the native sulphur or the metallic sulphide from which it is made. It was a Vermont Yankee who truthfully said that the ore in the ledge of pyrite in his back pasture was so rich that it would make more than its weight of acid. Recently at least one smelting company has perfected means of converting sulphur fumes into liquid sulphur dioxide, which can be shipped and made into gas at pulp mills without the elaborate and expensive devices that are needed to make this gas from sulphur or pyrite. By still another device, which has now almost reached the point of practical use, smelter fumes are converted into sulphur and thus yield a concentrated product which can be shipped at the least possible cost.

To give a clear conception of the dominant industrial position of sulphuric acid in time of peace a few of its more essential uses may be mentioned. In the manufacture of superphosphates from rock phosphate for use as fertilizer, a chemical process that makes the material more available as plant food, 2,400,000 tons of more or less diluted sulphuric acid, 74 per cent. of our normal consumption, is used annually. About nine per cent.

goes into the refining of petroleum; six per cent. is consumed in the iron and steel industries, largely for cleaning or pickling material that is to be either galvanized or tin plated; five per cent., or most of the output of concentrated acid, goes into the manufacture of explosives; and about six per cent. is employed for all other uses. These other uses, however, although they require a relatively small proportion of the total sulphuric acid made, involve the manufacture of a multitude of products that are absolutely essential to the entire chemical industry. Sulphuric acid is employed in making most of the acids commonly used in the laboratory and in manufactures, including hydrochloric, nitric, phosphoric, hydrofluoric, and boric acids. It is plain enough that if sulphuric acid and its derivatives were taken from the industrial chemist, he would be hopelessly handicapped. Many of his reagents could be manufactured in other ways, but the commercial success of all modern industrial processes is so largely dependent upon cost that the manufacturer who gets his materials most cheaply wins the race for markets.

We thus see how vitally our country is concerned in having a plentiful supply of this master chemical reagent. Let us now examine what effect the Great War had on the acid industry, inquire into the sources of the raw material from which it is made, and then determine how far our domestic supplies are adequate and how well the industry responded to the unusual demand and restrictions imposed upon it. In 1913, the last pre-war year, manufacturers in this country made the equivalent of 3,500,000 short tons of 50° acid and 23,000 tons of acid above 66°, and practically the entire output was required for ordinary commercial uses. Of this acid, 790,000 tons was produced as a by-

product in the smelting of copper and zinc ores, and the remainder was manufactured from 1,190,000 tons of pyrite, of which 850,000 tons was imported and 340,000 tons was produced from domestic sources. To state the facts in another way, 45 per cent. of the material we needed for making sulphuric acid was supplied from domestic sources, and 55 per cent. from imported ores. In 1917 the output in the United States was equivalent to 6,000,000 tons of 50° acid, an increase of 70 per cent. over 1913, and 760,000 tons of the stronger acid, above 66°, an increase of 3,300 per cent. If we measure the entire product as 50° acid, we shall see that during the first four years of the war the production of sulphuric acid in this country doubled. What were the demands that led to this great expansion in the face of increased cost of equipment and a growing scarcity of labor? The manufacturers of fertilizers certainly did not greatly increase their consumption, for their supplies of two of the essential ingredients of a complete fertilizer, nitrates and potash, were sharply curtailed. The answer is that all our industries were speeded up to supply munitions and to replace the great quantities of chemical products that formerly we obtained from Germany. Petroleum refiners strained every resource to meet the country's imperative demand for fuel needed for internal-combustion engines and for lubricants, and they use sulphuric acid in large quantities; iron and steel makers produced to full capacity and greatly enlarged their plants, and they are acid users; the dye industry, and indeed nearly every other branch of manufacturing in which sulphuric acid is used, was speeded to its limit to replace materials formerly imported and to keep up with the demands of the war; and, most important of all, the thirty-three fold

increase in the output of high-power acid was made in response to the insatiable demand upon America for explosives.

The problem that had to be solved in this emergency, in order that our industries and our war plans should not be crippled through lack of this indispensable material, was to obtain a supply of acid-making materials — either metallic sulphides, such as were used almost exclusively before the war, or some other form of cheap and available sulphur. Remember that in our pre-war practice domestic materials supplied less than half of our necessary acid. The output of acid from domestic materials in 1913 would not have been one-fourth enough in 1917. The demands in 1918 were even greater than those in 1917, and the estimates of the needs in 1919 were greater still. Furthermore, the shipping crisis necessitated an immense reduction in 1917 in the importation of Spanish and Portugese pyrite. The imports thus lost through lack of ships had to be made up by an increased use of our home supplies. Let us take stock of our American supply of acid-making materials — that is, our supply of the materials that can be obtained without the use of overseas shipping, including Canadian and Newfoundland pyrite, of which we used 214,000 tons in 1917. Our domestic production of pyrite in 1917 was 460,000 tons. We used in that year therefore, 674,000 tons of North American pyrite that was mined primarily for the manufacture of sulphuric acid. In addition, we imported 753,000 tons of Spanish and Portugese pyrite, making a total supply of 1,427,000 tons. This quantity is the equivalent of about 3,200,000 tons of 50° acid, and the copper and zinc smelters produced 1,450,000 tons of acid, making a total output from metallic sulphides of

4,650,000 tons. Figures themselves are dull unless interpreted, but these figures show that the acid produced in 1917 from materials that before the war constituted the only large source of supply came short of filling our demands by 1,350,000 tons of 50° acid and 760,000 tons of high-power acid. To meet that new demand for raw materials meant that it was necessary either to divert many ships from our vitally necessary trans-Atlantic fleet, or to utilize materials that in peace times had not been used for acid making. The manner in which this breach in the line of our industrial battle-front was filled is one of the great romances of American mining.

Late in the last century, in a search for oil and salt in Louisiana, the drills penetrated thick deposits of nearly pure native sulphur or brimstone. These deposits immediately attracted attention as a possible source of an adequate domestic supply of sulphur, but they were several hundred feet below the surface, and lay buried beneath a thick layer of quicksand through which it was almost impossible to sink shafts for removing the sulphur by the ordinary processes of mining. After many experiments, however, an ingenious process was devised for forcing superheated water down through the iron pipe of a well casing, melting the sulphur deep in the earth, and removing the melted sulphur through another pipe in the same drill hole. This system of removing the sulphur, the Frasch process, was gradually improved and utilized, so that the American marketed output of sulphur, which in 1900 was only 3,147 tons, rose in 1913 to 315,590 tons, and in addition large stocks of pure sulphur had been removed from beneath the ground and stored on the surface at the mines. This unique type of mining is represented by a small forest

of derricks, and the pile of sulphur in storage late in 1918 was as large as an office building six or eight stories high covering an entire city block. Through the exploitation of these deposits the United States in 10 years advanced from the position of a heavy importer of sulphur to that of the chief sulphur-producing country of the world. Here, then, was an immense source of sulphur for the acid makers. In times of peace sulphur sold at too high a price to be a serious competitor of the much cheaper pyrite, although a pound of sulphur will make more than twice as much acid as a pound of average pyrite. But since the war began and brought in its train a tremendous increase in the demand for acid, a shortage of ships to bring in foreign raw materials, and an increase in the cost of labor, the sulphur mines of Louisiana and Texas have been of inestimable value to us in our war work. In 1913 only 16,000 tons of sulphur was used in making acid. In 1917 about 463,000 tons of domestic sulphur and 20,000 tons of foreign sulphur was used by the acid makers, and the requirements for 1919 were estimated as well over 1,100,000 tons of native sulphur for acid making alone.

Before the war our output of sulphuric acid was made almost entirely from pyrite and from smelter fumes. We doubled our normal output in 1917 by using these large quantities of the sulphur produced in Louisiana and Texas, and this source practically accounted for the entire increase in the output of acid over our normal requirements. The use of native sulphur therefore is, the outstanding feature of our war programme in acid making.

In addition to the sulphuric acid made from pyrite and sulphur, a considerable quantity is made as a byproduct in the smelting of sulphide ores of the metals,

and the output of acid from this source may be greatly increased by a more complete utilization of smelter fumes. For example, in 1914 12 sulphuric-acid plants operated in connection with zinc smelters produced 300,000 tons of acid. At the end of 1917, in response to war demands, 18 plants recovered over 900,000 tons of acid from zinc ores. After the smelters have been equipped for saving their fumes, however, the production of acid will increase or decrease with the fluctuating output of metals rather than with the demand for acid, for the primary output of the smelters is metal, and the value of the acid by-products is too small greatly to influence the quantity of ore treated. Every ton of by-product acid represents a great bulk of noxious matter diverted to beneficial use.

So much for our war-time requirements of this vitally essential material and the manner in which our needs were met. The domestic production of acid responded to war demands by a tremendous increase in output, and from our own resources and from the foreign ore available the quantity of acid needed was produced. Let us now inquire what readjustments will take place with the return of peace and the reëstablishment of normal commercial activities. Now the commercial use of the raw materials no longer will be determined by convenience and availability, more or less irrespective of price, but will be controlled largely by their cost per unit of acid to the acid maker.

In the eastern part of the continent there are extensive deposits of pyrite along the Appalachian Mountains from New York to Alabama. Virginia alone has reserves of easily available ore which are estimated in millions of tons. New York has extensive reserves, and there are large deposits of pyrite in eastern Canada. The output

from all these deposits will doubtless be increased if for any reason free competition of European ores is prevented or restrained. In the coal-producing states of the Mississippi Valley, including Illinois, Ohio, and Indiana, a considerable source of pyrite not yet fully utilized is apparent in the nodules or so-called coal brasses found in coal and sorted out in preparing it for shipment. The limits of the supply from this source must be fixed by the quantity of pyrite in the coal mined, for the pyrite is nowhere sufficiently abundant to justify mining it for itself alone. The coal brasses form, in fact, an impurity in the coal, and great quantities have been hand-sorted out of the coal merely to improve its fuel value and have been left in the worked-out galleries of the mines. Colorado and the other Rocky Mountain states have great reserves of sulphide ores, and California has reserves which may be reckoned in millions of tons. Sulphide ores are smelted throughout the country in immense quantities and yield enormous amounts of sulphur, only a fraction of which is now used for making acid. Finally, we have the sulphur mined in Louisiana and Texas and now extensively used in making acid. Although the deposits already known in these states contain several million tons of sulphur, the present enormous demand upon them will exhaust them in a few years. Perhaps other beds will be found, but the reserves cannot be considered inexhaustible. There are other deposits of sulphur in the United States, but they are much smaller than those in Louisiana and Texas, and are likely to be of local, rather than national, interest.

The foregoing summary of our reserves of materials now available for acid making indicates that we undoubtedly possess sufficient sulphur, in its various forms, to make all our acid for generations, but we must deter-

mine where sulphur can be produced and landed at the acid works most cheaply, for the cost of acid will have a large influence on the degree of success that our chemical industries achieve in meeting foreign competition after the war. It is obvious that the raw materials for acid for our great industrial centers on the Atlantic seaboard must be obtained either from American deposits that lie close enough to insure a low freight rate, or from such other parts of the world as have cheap ocean rates to our Atlantic ports. The sources of acid-making materials available for use at our eastern industrial centers have heretofore been the pyrite deposits of eastern Canada and of New York and Virginia and the Spanish and Portuguese pyrite mines. In the Huelva district of Spain and an adjoining part of Portugal there are pyrite deposits which are much larger than any other developed ore bodies of this kind in the world. Reliable estimates place these reserves at between 250,000,000 and 300,000,000 tons — enough to supply the entire world, at the rate of consumption in 1913, for 50 years. Furthermore, the Spanish pyrite contains a small but valuable amount of copper, which gives it a commercial advantage over pyrite ores that contain no copper. The Spanish and Portuguese mines have been worked on a large scale, have elaborate shipping and terminal facilities, and in time of unrestricted ocean commerce their product is likely to continue to compete in our east-coast markets with American-mined pyrite. Norway also has great reserves of pyrite which are available for shipment to our Atlantic ports. Our eastern pyrite mines were gradually increasing their output up to 1913, and even when the shipping conditions of 1913 should be restored, they doubtless would increase their output still further. It seems doubtful, how-

ever, whether this increased output would more than supply our normally growing demand for acid. The output of coal brasses from mines in the Mississippi Valley can be largely increased, but only within definite limits. The pyrite deposits of California could probably maintain a higher rate of production than they have made heretofore, and could supply a large quantity of acid for Pacific-coast consumers, but the long haul to the eastern market, either by rail or by water, will always bar California pyrite and acid from this market under normal commercial competition.

The future promises a greatly increased production of sulphuric acid as a by-product in the smelting of sulphide ores. In roasting these ores large volumes of sulphur-bearing gas are thrown off, and the common practice has been to allow this noxious gas to escape into the air, to the great damage of vegetation in the neighborhood. Laws have been enacted in some states to require the smelters to abate this nuisance, with the result that this waste product is being converted into sulphuric acid. The smelters in the Eastern and Central States are able to market this by-product acid in competition with that manufactured from pyrite, but the high freight rates compel those western smelters that recover by-product acid to market their acid in territory near them.

A question of the utmost concern to the users of acid, the acid makers, and the producers of both pyrite and sulphur is the extent to which our native sulphur will continue to be used for making acid after the war. A factor that has great influence on any change in industrial practice is the inertia, sometimes termed conservatism, of the manufacturers, as shown by their tardiness in adopting any new practice that involves considerable

change in procedure or equipment. The recent phenomenal increase of the use of sulphur for making acid was due to the shortage of pyrite. The shipment from overseas were curtailed, and the domestic pyrite mines were unable to supply the deficiency and to meet the suddenly increased demand. The acid makers were thus compelled to turn to the native sulphur mines, which were producing more sulphur than was needed to supply the demand and had accumulated great stocks of mined sulphur. In a short time the war thus caused a change in practice that otherwise might never have occurred on so large a scale. With the restoration of peace certain acid makers will doubtless continue to use native sulphur, unless acid can be made from other materials more cheaply than from sulphur. The sulphur in the Gulf states lies far from our great acid-consuming centers, but a ton of sulphur produces more than twice as much acid as a ton of pyrite, so that sulphur will stand a much greater freight charge than pyrite and still yield acid at a lower cost per unit. On the other hand, the cinder from roasted pyrite is an available iron ore, and has a value that may offset entirely or in part the greater cost per unit of acid.

A review of the whole situation indicates that in the future, as before the war, acid will be made chiefly from pyrite and other metallic sulphides rather than from native sulphur. The average price for domestic pyrite at the mines in 1913 was $3.77 a ton, as compared with $17.58 for sulphur, and the average prices in 1917 were $6.37 for pyrite and $22.93 for sulphur, and in 1918 about $10.00 for pyrite, and $22.50 for sulphur. Even if we concede that sulphur is easier and more satisfactory to handle in an acid-making plant and yields over twice as much acid as pyrite, and that manufacturers

equipped to burn sulphur will change their practice reluctantly, it nevertheless appears that the lower cost of raw material will give the pyrite user a decided advantage over his rival who burns sulphur unless that advantage is offset by a favorable location of the plant with respect to the sulphur mines. It seems safe to predict, therefore, that with the return of peace the larger part of our sulphuric acid will be made from sulphide ores. If, on the other hand, sulphur could be marketed at $10 or $12 a ton when pyrite brings $4 to $5, there is no doubt that sulphur would continue to be a large source of acid. If an abundant supply of both sulphur and pyrite is available, the practice of acid makers will be determined by the cost at which they can place their acid on the market. As a matter of good national policy, however, it might be well to consider the desirability of using the cheaper and more abundant pyrite to as large an extent as possible in making acid, in order to conserve our less plentiful but purer sulphur for purposes to which pyrite is not so well suited, or not suited at all. In making wood pulp also sulphur is an essential raw material, about 150,000 tons a year being used in this country for making sulphide pulp, and a large quantity being exported to Canada for the same use. The great pulp industry is now largely dependent upon sulphur obtained from Louisiana and Texas, and it has been suggested that pyrite, which is perhaps less attractive for burning into gas at the pulp mills, be substituted for sulphur to save both raw material and transportation. Pyrite can be profitably used for pulp making and is now so used at some mills. With undeveloped pyrite deposits near at hand, it seems poor national economy to haul the less abundant sulphur from the Gulf coast to New England, Wisconsin, and Canada.

The story of dye making in the United States and its growth within a few years from a small, struggling industry to its present proportions is complex and technical in all its details, yet an outline of it is of importance here because of its relation to our mineral industry. Most of our present-day dyes are of mineral origin, for they are derived from products obtained in the distillation of coal in coke making. Before the war Germany had long controlled the dye output of the world. Although our iron makers called for immense quantities of coke, most of the coke was made in beehive ovens, from which the volatile matter in the coal was discharged into the air and lost with all its contained by-products, largely because there were no domestic industries to use these products. A number of attempts were made by Americans to establish chemical works to use coal-tar products, but the powerful and strongly intrenched German companies, by various devices in which Germany was expert, contrived to make the American manufacture of coal-tar products unprofitable.

In 1909, however, three strong American companies, all of which were directly interested in the chemical industries and in coal-tar products, united to form a company, the Benzol Products Company, to manufacture the so-called coal-tar intermediates, especially aniline oil, which is used so largely in making many dyes. In that year its plants made a large quantity of aniline oil, but the appearance of this American product on the market was the signal for the dumping in this country of a great quantity of German aniline oil at prices less than the cost of manufacture here, if not, indeed, in Germany itself. The American company persisted, however, and the commercial struggle of this new industry against the strong German dye combination was in full

course when the war broke out in Europe in the summer of 1914.

The Allied control of the seas and the removal from ocean commerce of all German shipping immediately cut off the great bulk of German dyestuffs from the American market. Germany's monopoly of the dye industry had been almost complete, not only in America but throughout the world, and the dye shortage was felt immediately in all Allied countries and in those neutral countries that were cut off from German imports. For some time after war was declared, before the United States joined the belligerents, small quantities of dyestuffs came to this country from Germany by way of neutral nations and on board the *Deutschland,* but these supplies were far too small to supply a hungry market. As early as 1915 we were suffering from an acute shortage of dyes and could get no help from any of the nations with which we had commercial relations, for they were as hard up for dyes as we. The only possible source of the dyes upon which our textile makers were wholly dependent lay in our own devices;—we had to build our own chemical plants and make our own dyes, and this was a work of tremendous technical difficulty.

The dye industry is one of the most highly specialized branches of chemistry, and in Germany it had been built up on the results of years of laboratory work by a great corps of dye chemists. The results of much of this work were in the hands of the Germans only, and many of the processes were secret. To establish an industry in the United States that would meet our needs for dyes meant, therefore, the working out anew of the chemical procedure and the training of a great number of dye chemists, the construction of plants and equipment to make the dyes, and changes in by-product coke

oven practice to save certain necessary dye-making materials, notably the benzol oils.

The growth of by-product coke making is an index to the growth of the industries that depend upon coal-tar products. The mineral that furnishes the original source of supply is coal, and our unsurpassed reserves of coal can yield, of course, enough coal-tar products to supply our needs for generations.

The distillation of a ton of average coal into coke produces about 1,500 pounds of coke, 10,000 cubic feet of gas, 22 pounds of ammonium sulphate, over two gallons of benzol, and nine gallons of tar. At ordinary commercial prices the value of the by-products is considerably greater than that of the coke. These figures at first seem to show that the operation of by-product coke ovens should be highly profitable as compared with the operation of beehive coke ovens, which lose all the by-products. Nevertheless, the wasteful beehive ovens have been replaced rather slowly by by-product plants, and the reasons for this slow change are easily found. In the first place, a by-product plant itself is expensive, its cost of operation is rather high, and to yield the greatest profit it should make the fullest use of all the products obtained from the coal. The coke finds a ready market with iron makers. In fact, nearly all the by-product ovens are owned by steel manufacturers. The market for the by-products, upon which the success of by-product coke making depends, has expanded only gradually, and to overproduce by-products was to court disaster. The rate of installation of by-product ovens, therefore, has followed the demand for coke and for the coal-tar derivatives. The accompanying diagram[2]

[2] C. E. Lesher, U. S. Geological Survey, *Mineral Resources of the United States,* 1915, Pt. 2, p. 517 (1916).

(Figure 12) shows graphically the output of by-product and of beehive coke and their relations to the output of pig iron from 1893, when by-product coke was first produced in considerable quantities, to 1917. The only two depressions in the ascending curve for by-product coke output occurred in 1908 and in 1914, and both cor-

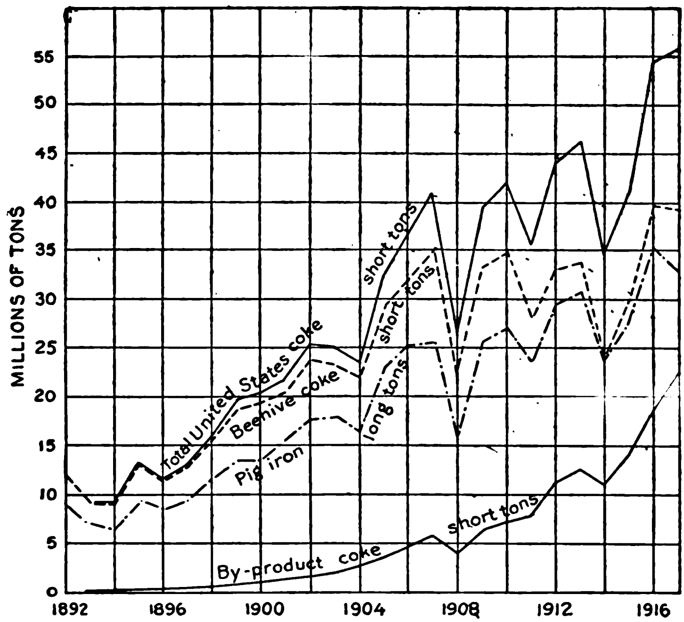


FIGURE 12. PRODUCTION OF BEEHIVE AND BY-PRODUCT COKE AND OF PIG IRON IN THE UNITED STATES, 1892-1917

respond with depressions in the curve showing the output of pig iron.

We have seen that in 1915 the American manufacturers of textiles had about exhausted their stocks of dyes, were cut off from their previous source of supply, and could turn for help to no well established dye in-

dustry in this country. The problem that confronted the nations was to develop a great, highly organized industry almost overnight. In that year the industrial stimulus due to the American manufacture of munitions for the Allies caused a great increase in our production of pig iron, and with it a record-breaking output of coke. Both beehive and by-product coke shared in the increase, but the prevailing high prices for toluol and ammonia, both of which are coke-oven by-products needed in the manufacture of explosives, stimulated the building of by-product ovens, which numbered 5,808 in 1914, 6,268 in 1915, 7,283 in 1916, and 7,869 in 1917; in 1917, for the first time, the output of by-product coke continued to increase while at the same time that of beehive coke fell off. The tendency toward the gradual increase of by-product coke at the expense of beehive coke is shown by the fact that in October, 1918, for the first time, the monthly output of by-product coke exceeded that from beehive ovens, and although the figures for 1918 show that beehive coke constituted more than half of the total for the year, it is likely that in 1919 and thereafter by-product coke will furnish the greater part of our needs.

This constantly increasing number of by-product coke ovens furnished a large supply of materials which were available for making dyes. Through strenuous concentration of effort our chemists solved many of the technical problems and, almost before we knew it, brought into existence a new industry. In 1917 more than 80 establishments in this country were making coal-tar dyes, of which they produced for our own use nearly 46,000,000 pounds, which replaced an almost equal amount of dyes imported in 1914. In addition, many million dollars' worth of dyes were manufactured for export. It must not be understood that all the tricks of the trade,

chemical formulae, and methods of procedure that had been learned by German dye makers during years of patient labor and study have been rediscovered and applied by our own chemists in less than three years, or that all the German dyes have been duplicated. Our output in 1917 did in fact duplicate many of their products, but much still remains to be done, and the gaps in the processes must be filled gradually. Most of the staple dyes now are being produced in quantity, and the only shortage to-day is in the variety of dyes available. In times of peace many special dyes were made from toluol, but nearly all the available toluol has been used in making explosives, and the output of dyes that require this material was somewhat restricted while the war lasted. Enough by-product coke ovens are now in operation in this country to supply all materials needed in our dye industry. The continued expansion of by-product coke making at the expense of scrapping the wasteful beehive ovens is to be expected, and will make our coal increasingly useful, for the large and constant supply of coal-tar products available will encourage other industries that use these materials to enter the commercial field. The ultimate goal to be reached in this phase of our effort to achieve economic independence and to make the greatest possible use of our coal resources is a coke-making industry in which all the coke is made in by-product ovens, the products of which are fully used as the raw materials for other manufactures.

The value of a complete dye industry as a national asset is not to be measured by the pounds of dye produced, nor by the dollars for which the dyes are sold; it is much more fundamental. Dye making has well been called a key industry, for our entire output of woolen and cotton goods, rugs, carpets, and a multitude

of other commodities is dependent upon a plentiful supply of unsurpassed dyestuffs, and the value of all these finished articles is many times that of the dyes used in their coloring. It was this indirect control of other industries that made the German monopoly in dyes a barrier to our national industrial independence and a menace to our national prosperity.[3]

The manufacture of chemical fertilizers is already the largest branch of industrial chemistry, and the use of mineral fertilizers in this country is certain to increase greatly. The soils on which we raise our crops naturally differ in character from place to place, and the fertility of most of them can be improved by the addition of certain chemical elements that are present in insufficient amounts or are wholly lacking. Furthermore, the crops themselves exhaust the soil of mineral plant foods, and continued large crops can be had only by resupplying in some form the plant foods thus withdrawn. Most European farmers have already learned this lesson; the intensive farming practiced in the densely populated European countries is made possible only by the generous use of fertilizers. As our country becomes more closely settled and the demand for larger crops per acre increases, we too will come to think of soil fertility less as a gift of Providence than as a result of our own good farming and of our willingness to give back to the soil the plant food it must have to yield good harvests.

The growing plant needs many chemicals, most of which are sufficiently abundant in the average soil.

[3] The maintenance and protection of the dye and other chemical industries created or stimulated by the war are discussed at length in this series in W. S. Culbertson, *Commercial Policy in War Time and After.*

Three, however, all vital to plant growth, are rather easily exhausted from the land, which, losing them, loses also fertility. These three are potassium, nitrogen, and phosphorous, or, as the chemical compounds in which these elements are available as plant food are called, potash, nitrates, and phosphates. These three substances, in various forms, are the principal ingredients of all chemical fertilizers, and abundant supplies of all three are necessary to keep our soils fertile. It is unfortunate that commercially available deposits of these materials are not at all common, and such as do exist are rather sharply localized throughout the world. It so happens that although deposits of phosphates are somewhat widely distributed throughout the world, commercial deposits of potash and nitrates before the war were found only in single countries — potash in Germany and nitrates in Chile, so that these countries controlled the world's supply of these essential minerals.

Potash is a highly valuable fertilizer for many crops, as it stimulates the growth of the fibrous parts of plants, helps the crops to mature, and improves the quality of fruits and flowers. The potash supply of the world had been in the hands of a powerful German syndicate, protected, and, in fact, partly owned, by the Prussian Government, which doled out this essential plant food to the world at prices arbitrarily fixed by the syndicate. The German potash monopoly was made possible through German possession of the world's largest deposits of potassium salts. Although potassium is widely distributed through the soils and rocks of all parts of the world, it occurs mostly in forms which are insoluble in water and which are therefore not available as plant food. It is true that minerals containing insoluble potash can be so treated chemically as to convert the potash

into fertilizer, but all the processes thus far devised for this purpose are so expensive that the product cannot compete in the market with the cheaper natural salts mined in Germany. Although potash is needed chiefly for use in agriculture, small quantities of it are imperatively required for use in many other essential industries. It is needed in making high-grade soaps, glass, matches, and certain explosives. The chemical needs, although they consume only a small part of the potash we use, are absolutely imperative, and must be met before other needs are supplied.

The several kinds of commercial potash salts marketed differ in their content of potassium, and in order to avoid confusion, the figures showing the output of the different kinds have been recalculated, so that the figures here given represent pure potassium oxide or potash (K_2O), the chemical for which most of the salts are purchased. Our domestic requirement of potash in times of peace, as indicated by our imports in 1913, was 240,000 tons, of which 95 per cent. was used as fertilizer. Nearly all of this amount was imported from Germany. The prices of this potash, as fixed by the German potash syndicate, were high, yet the American buyers had no recourse. Potash was thus the raw-material weapon with which Germany threatened the commercial world, and especially the United States, for we took over half of her exports. The German beds are of immense size. The largest deposit, around Stassfort and extending to the Harz Mountains, is, so far as known, 250 miles long and 140 miles wide, and other extensive beds have been found in Alsace. Efforts had been made to find similar beds of buried salts in the United States, but with little success, and there seemed to be no escape from the grip of the potash syndicate.

With the outbreak of the war our imports of potash from Germany were cut off, and there was none to be had elsewhere. Prices increased by leaps and bounds; they were in 1918 about 10 times greater than normal, and our stocks of German salts were exhausted. The chemical demands for potash were greater than ever, and these must be supplied first, but the need of potash for use as fertilizer for certain crops is well shown by the fact that the greatest part of our present scant supply goes into agricultural use, even at the tremendously high prices now prevailing. However, in view of the fact that staple food crops, not only in this country, but in Canada, England, and France, were excellent in 1917, whereas according to all neutral accounts German crops were exceedingly poor, the questions arise: Why does not Germany take her own potash medicine, and is potash, after all, an absolute necessity for all soils and all crops?

With such extraordinary prices prevailing, every possible source of domestic potash was closely examined from the early days of the war; but although our geologists and chemists knew where potash was to be found, practical difficulties were met in devising processes and plants for extracting it at the greatest profit, and about a year went by before any considerable output was made. In the second half of 1915, however, potash began to enter the market from several domestic sources.

Certain alkaline lakes in western Nebraska, California, Utah, and Nevada were found to contain recoverable potash, and plants for obtaining this potash, soon started, still supply much of the largest part of our domestic output. The potash in these alkaline lakes was once in the soil and rock of the surrounding area; through natural

action over a long period it was dissolved out by water and concentrated in the lakes from which it is now being taken by man to be returned to the land.

Certain varieties of seaweed known as kelp contain potash, and they have long been used in their raw state as fertilizer. These sea plants grow thickly over great areas along the Pacific coast, and the potash they extract from the sea water, along with iodine and other valuable products, can be recovered by a rather simple process. Machines specially constructed for harvesting this ocean crop were devised, and several companies began to produce potash from kelp in 1915. The output from this source was over 3,500 tons in 1917. Our farmers of the sea are thus harvesting a crop of fertilizer to make the land farms more productive. The use of kelp for potash is a real saving, for it represents the recovery of potash that had been dissolved from the land and apparently lost for ever in the ocean.

Alunite, a mineral of wider distribution than was formerly realized, contains potash, and plants were built for extracting potash from alunite at Marysvale, Utah. Another interesting experiment was that of saving the potash in certain industrial wastes, including molasses residue, the by-products of sugar refining, and wool scourings; and all these waste products are now helping out by returning to the land the mineral salts recently taken from it by the plants. Dusts from blast furnaces and cement mills contributed their quota, and return has even been made to the use of the primitive pots and wood ashes which were the first source of potash and from which this product got its name.

From all these sources we produced less than 1,000 tons of potash in 1915, or scarcely two-fifths of one per cent. of the quantity required to supply our ordinary

needs. In 1916 the domestic output was increased ten times, to nearly 10,000 tons, or about four per cent. of what we should have had. In 1917 it was increased to over 32,000 tons, 13 per cent. or our normal requirements, and the record for 1918 will show a domestic production of 25 per cent. of our pre-war requirements, a

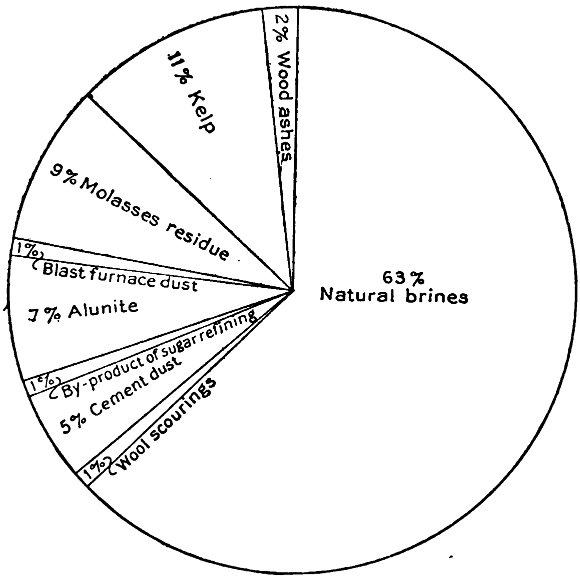


FIGURE 13. RELATIVE IMPORTANCE OF SOURCES OF POTASH (K_2O) PRODUCED IN THE UNITED STATES IN 1917. THE TOTAL PRODUCTION WAS 32,509 SHORT TONS

still closer approach to our independence of Germany. The accompanying diagram (Figure 13) shows the proportion of pure potash recovered in 1917 from each of these sources of supply. It must be admitted, however, that the potash from most of these sources, including the kelp fields and even many of the alkaline lakes, has been marketable only because of the abnormally high prices at

which potash is now sold, and it is certain that many plants will be closed as soon as the German potash is again put on the market.

Fortunately there are two sources of potash, now only beginning to be utilized, that may supply most of our requirements at reasonable prices and thus make us largely independent of the German syndicate. These are the dusts from cement kilns and from the blast furnaces of iron works. Analyses of these dusts show that they contain considerable amounts of soluble potash, the amount depending on the character of the charge placed in the furnace and on the method of treatment used. Processes have recently been perfected for saving the dusts economically, and a larger part of their content of potash will no doubt be saved when the plants are better equipped. It is reported that one California cement plant recovered enough potash to pay the entire cost of its operation, and that in this plant the potash is the most valuable product; for the time being the cement may be considered a by-product. Various estimates have been made of the quantity of potash now being lost through failure to save these dusts. One reliable estimate shows that the quantity of potash contained in cement-plant dusts is 100,000 tons a year, of which 50,000 tons can be recovered at a profit. Another estimate shows that the quantity of recoverable blast-furnace potash is from 150,000 to 250,000 tons a year. No doubt both these amounts can be increased if the materials used in the cement and iron plants are selected for their high content of potash. Practically no potash was recovered from these sources in 1914. In 1916 perhaps 1,000 tons was saved, and in 1917 about 1,800 tons. The output will show a large increase in 1918, and it may be that the supply of this by-product potash, which until now has

been literally going up in smoke, will be equal to our entire pre-war demand. All the potash obtained from cement and blast-furnace dusts, from alunite, and from such materials as leucite and feldspar represents a real contribution to the world's supply of fertilizer, for in their natural state these potash minerals are not available as plant food. Most of their potash has never been in either soil or vegetation; it represents a part of the earth's original content of potash, now for the first time to become a part of growing plants.

Still other sources of potash may help to free us from the grasp of the German trust. Spain is believed to have large reserves of natural salts which may help to break the monopoly, and in Alsace there will be available to us supplies of potash in the hands of another friendly nation. With competition between Germany, France, and Spain for the American market, and with our increasing domestic output and possibilities, the prospects for a future cheap and abundant supply of potash for the American farmer look much brighter than when the single source of supply was in the hands of the Germans, and our own notable progress in developing a supply is good defense, politically as well as economically.

As a result of the high price of potash salts, our chemists have found that sodium compounds may be used satisfactorily for many purposes for which potassium compounds have commonly been employed. Thus potassium cyanide, which was required in large quantity by gold miners to dissolve the gold from ores of that metal, can be replaced by sodium cyanide by simple changes in the apparatus now employed. Sodium compounds have replaced potassium compounds to a large extent also for making glass, soap, and matches, as well as in photography and in tanning. As most of our soda is made

from salt and limestone, both of which we have in almost unlimited quantities, the substitution of soda for potash is a true measure of conservation; it uses our inexhaustible supplies of salt and saves the more precious and rarer potash for other purposes.

The second essential ingredient of a complete fertilizer is nitrogen, or nitrates, as the salts of nitrogen available as plant food are called. Nitrates are particularly valuable in stimulating the growth of plant foliage. Nearly all the world's supply of this material has been obtained from the rainless area of northern Chile, where extensive deposits of rock and soil are impregnated with nitrate and other salts. These salts are soluble in water, and they have been preserved in that place only because of its nearly complete lack of rainfall and of drainage. Nowhere else in the world have deposits been found so rich or so large as those in Chile, and their owners have had, therefore, a nearly complete monopoly of the world market for nitrate. Thus, singularly, one of the most barren of all deserts supplies increased fertility to cultivated fields in other parts of the world. It is true that nitrogen may be and is obtained from other sources — from sulphate of ammonia and ammonia liquor produced in the by-product coking of coal, from the atmosphere, and from many organic materials, including cottonseed meal, slaughter-house refuse, and fish scrap; but in normal times the output from all these sources has been small compared with that of the Chilean salts, which have dominated the market and determined the price of nitrates obtained from other sources.

The quantity of nitrates required in the United States in times of peace, as shown by the consumption in 1913, was 650,000 tons, of which about 35 per cent. was used in

making explosives, 50 per cent. as fertilizer, and 15 per cent. for other chemical uses; and by far the greater part of this supply was imported from Chile.

At the outbreak of the war tremendous changes were made in the nitrate industry. Nearly all the high explosives used in modern warfare are compounds of nitrogen, and nitrates thus became of prime value to the belligerent nations. Germany was at once cut off from her supply of Chilean nitrate, but with great military foresight she had accumulated a large reserve of this material for use in just such an emergency. She had not foreseen, however, such a war as the late titanic struggle, and when it became plain that the war would be great and long, she faced a serious crisis, one that might have been disastrous had she not hastened at top speed to exploit all possible sources of nitrates. Her by-product coke industry was highly developed and was made to yield large quantities of sulphate of ammonia, and she rapidly started plants for the fixation of atmospheric nitrogen; but all her preparations might have been too late, and she might have been defeated through lack of explosives made from nitrates, if she had not captured large stores of nitrates in Belgium which tided over the Central Powers until their plants for making atmospheric nitrates were in operation.

In Chile the immediate result of the declaration of war was a slump in the nitrate market, owing to the world-wide industrial depression and to the loss of the trade with Germany. Soon afterward, however, the Allies' needs for explosives increased mightily and production responded. The situation for the Allies and for the munitions makers of the United States was made uncomfortable by the peril due to the presence of German raiders on the seas, for any long interruption of the

nitrate trade with Chile would have spelled disaster. The fact that the German fleet later destroyed in the battle off the Falkland Islands chose the waters near South America as the scene of its operations might well have been a plan to cut off our nitrate imports from Chile. This peril became constantly greater through the loss of ocean-going ships occasioned by Germany's submarine campaign, and after the United States entered the war a sufficient domestic supply of nitrates became not only desirable, because even more imperative, but essential.

In war time the call for munitions must be answered first. Ordinary industrial needs must wait on the military demands. Nevertheless, food is as essential a war commodity as powder, and food indeed helped to win the war. How, then, was the demand for nitrates for powder to be balanced against that for the fertilizer required to grow big crops, and how were the increasing demands for both purposes to be met when the call was unceasing for more and more ships for the trans-Atlantic traffic? These were great problems, and upon their proper solution depended the outcome of the war. Three conflicting factors, namely, the shortage of ships, the new demand for explosives, and the increased needs of the farmers, had to be considered. The Shipping Board found that there were no ships to spare for bringing Chilean nitrate to both powder makers and fertilizer makers, yet explosives must be furnished to our army and to our allies. If it were possible, even those ships used in the Chilean trade would have been diverted to more essential uses elsewhere.

Our increased needs for nitrates is shown by our importation from Chile of 1,556,000 tons in 1917, as compared with 686,000 tons in 1913, an increase of 126 per cent., and this in the face of an acutely felt shortage of

ships. All this increase, and more, was needed for munitions. The nitrate required in 1918 was thus diverted from its normal courses, in which fertilizer was the largest item, to military use, which was six times greater than its present use in agriculture, and an increasing shortage of nitrate thus became more and more possible.

It is plain that if we lacked sufficient nitrates, our war plans would come to naught. It is equally plain that with the main source of supply in the hands of another nation, with the necessity of bringing the material several thousand miles by water, and with an interruption of imports by no means inconceivable, we would be criminally negligent to leave so vulnerable a point open to attack.

Certainly our only safe course was to obtain at any cost from domestic sources the nitrates to supply at least our war needs, in much the same way in which Germany had already been forced to supply herself. Intensive search for natural supplies of nitrate salts in this country has proved disappointing. Although our western deserts contain beds of nitrate-bearing materials which are similar in general character and origin to those in Chile, they are very small and are so poor in the salts desired that they can be worked only as a last resort, because they involve excessive expenditure of labor. Our problem, therefore, was to obtain nitrogen in some other way, and the means had already been pointed out by our enemies — to draw upon the inexhaustible supplies of the atmosphere.

There are several well-developed methods of extracting nitrogen from the air and fixing it in forms available for use in making either explosives or fertilizer. The possible supply is unlimited, but the processes are all expensive as compared with the cost of mining and ship-

ping Chilean nitrates; elaborate equipment is necessary and large amounts of power are consumed. Here we have another conflict of interests which must be adjusted, for all our present sources of power are needed in other kinds of industry, and the coal output is limited by the supply of labor and cars. Cost, however, has been made subordinate to our need for a nitrate supply of our own, and appropriations have been made by Congress for building great nitrogen-fixing plants, which are now under construction. It is estimated that these plants, when completed, will be able to produce nitrates in an amount equal to our entire pre-war consumption. Private industrial plants were encouraged to produce nitrates, the by-product coke ovens yielded an ever-increasing amount of ammonium sulphate and ammonia, and the importation of Chilean nitrate continued. Yet the demand for explosives had grown so large, and the need for ships was so pressing, that the quantity of nitrates which could be spared for fertilizer in 1918 was greatly reduced.

By tremendous effort and at great expense we thus strengthened the offensive power of our army. With the return of peace we are a step nearer the goal so desired by every nation — economic independence in essential raw materials. Our nitrate plants, no longer needed to produce the means of destroying our enemies, are immediately available for the constructive work of peace, furnishing the means for restoring our weakened soils and thus feeding our people. No one can say whether or not nitrogen-fixation plants can be operated at a profit in competition with the Chilean nitrate fields, but the strategic value of having an assured supply of a material that is vitally needed for war may more than offset the greater cost of production, and the very fact that we are

able, if necessary, to produce the fertilizer we need may well serve as a check upon the prices demanded by foreign nations for such nitrates as we may import. It will be good national policy to keep our nitrate plants operating, even though not to full capacity, in order that we may be prepared to defend ourselves from attack, either by an armed enemy or in the bloodless but no less keenly fought contests for markets.

The third necessary ingredient of a complete fertilizer is phosphorus, which is obtained from various phosphates. These phosphates, when applied to the soil, break up and release phosphoric acid, which increases the yield of crops and hastens the time of their maturity. The phosphates are obtained principally from natural phospate rock, which occurs in extensive deposits in many parts of the earth, and from basic-slag phosphate, which is obtained as a by-product in the manufacture of steel from phosphorus-bearing pig-iron by the Thomas process. Nearly 7,000,000 tons of natural phosphate rock was mined in 1913, of which the United States produced over 3,100,000 tons; Tunis, 2,280,000 tons; and Algeria, France, Belgium, and the Christmas Islands, from 150,000 to 450,000 tons each. A large part of the remaining phosphate used for fertilizer in 1913 was basic-slag phosphate, of which Germany produced about 2,250,000 tons; France, 700,000 tons; Belgium, 650,000 tons; the United Kingdom, 400,000 tons; and other European countries smaller amounts, the total European output being over 4,000,000. Not much basic-slag phosphate is made in the United States, as the iron ores used here contain very little phosphorus. The above figures show that each of the great commercial nations of Europe has a considerable supply of phosphates,

although, except those produced in the United States, Tunis, and Algeria, most of the phosphates are a by-product of steel making, so that the production must vary with the amount of steel made rather than with the demand for fertilizer.

It is plain that phosphates, unlike potash and nitrates, are not monopolized by any single nation. Nevertheless, the United States is particularly fortunate in the quantity, quality and distribution of its phosphate deposits, and has been a heavy exporter of phosphate rock to Europe and to other parts of the world. Of our output of over 3,100,000 tons of phosphate rock in 1913 we exported 1,360,000 tons, or about 44 per cent., which offset to some degree our necessary imports of the other fertilizer materials, potash and nitrate. In 1913 nearly all the phosphate we exported and almost five-sixths of our entire output came from Florida, where phosphate mining has been extensively developed.

Fertilizer is bulky and is therefore subject to heavy charges for shipment, so that the distance of the source of supply from the fields on which it is to be used has much to do with the price at which it can be sold to the farmer, and is likely to determine the quantity he can afford to use. In a country of such magnificent distances as ours, an unbounded supply of phosphate in Florida might be of no benefit to the beet grower in Utah, for the freight haul of several thousand miles would add tremendously to the cost of the prepared fertilizer. Fortunately our phosphate beds are widely distributed and of unequalled size. Florida, Tennessee, South Carolina, Kentucky and Arkansas all have reserves to be measured in millions of tons, and these beds can supply the eastern and central states with only moderately long freight hauls. In Utah, Idaho, Wyoming, and Montana

there are even greater supplies. In the group of eastern states mentioned there are estimated reserves of nearly 350,000,000 tons of phosphate rock; in the western states the reserves amount to nearly 5,500,000,000 tons, a total sufficient for our own needs, at the present rate of use, for 3,300 years.

The utilization of our supply of phosphate, however, does not depend entirely on the distribution or location of the raw phosphate rock, but is dependent in part upon the manufacture of sulphuric acid. Raw phosphate rock contains phosphorus in a form in which the plants are unable to use it. To make the phosphorus available for use as fertilizer it is necessary to treat the raw, finely ground rock with sulphuric acid, the treatment producing soluble acid phosphate. To produce fertilizer, therefore, sulphuric acid in quantity is as necessary as phosphate rock, about a ton of 50° acid being needed to treat each ton of rock. The prepared acid phosphate thus obtained is about twice as heavy as the raw rock, and to reduce or avoid freight charges on this material it is desirable to have both phosphate rock and sulphuric acid as near the point of consumption of the fertilizer as possible. Although in 1917 we produced about 6,400,000 tons of artificial fertilizer, the average freight haul on the manufactured product was only 127 miles. It so happens that our greatest supplies of phosphate, which are in the western states, are in areas near which the sulphide ores of the metals are extensively mined, and the smelting of those ores produces sulphur fumes from which sulphuric acid can be made. A part of the sulphur thus produced is already used for making acid which is employed in preparing phosphate fertilizer. As the demand for fertilizer grows, the smelters will be encouraged to save increasing amounts of acid-making

fumes, and a waste product will be converted in this way into a most useful and valuable commodity.

In this large and newly settled country, where wild lands have been offered to the homesteader at nominal prices, the tendency has been to increase our supplies of agricultural products by planting an ever-increasing acreage, rather than by making larger crops by fertilizing and farming better the land already cultivated. The day has now come when the lands most easily reclaimed have been taken up, and the value of farm lands has greatly increased, so that the food supply for a rapidly growing industrial population must be raised from the arable lands we have. This prospect is not discouraging if we have the necessary materials for making chemical fertilizers, but in order to attain our greatest national development we should be self-contained in the supplies of raw materials needed to stimuate our fields to yield their greatest crops. As has been shown, we have made long strides in the last four years toward a condition of self-sufficiency in fertilizer minerals. The fact of, perhaps, greatest promise to those who are seeking the conservation and proper utilization of our resources is that a large part of our fertilizer materials will be gained by saving things that we have hitherto wasted or by using supplies that are not subject to exhaustion. Thus, the sulphuric acid for phosphates was wasted at the smelters; the potash from cement mills and blast furnaces was lost into the air; the kelp of the Pacific Ocean lived and died unutilized; the potash from several industrial waste products simply polluted our streams; nitrates in large quantity were lost in the wasteful coking of coal in beehive ovens; and the inexhaustible atmospheric supply of nitrogen was not

courage the greater use of fertilizer by cheapening its cost to the farmer. As has been shown, a large part of the cost of fertilizer is the freight on the ingredients from the deposits to the factory and thence to the farm. Our total output of chemical fertilizers in 1917 was about 6,400,000 tons. Naturally any increase in the concentration of this product — that is, in the amount of plant food per ton of commercial fertilizer — would give a greater fertilizing capacity per ton of transported material. The present commercial fertilizers contain a large quantity of inert material, which in no way benefits crops, for the raw phosphate rock is never pure, and in the present practice of preparation no attempt is made to purify it after it is ground. Furthermore, as the three important constituents of the marketed fertilizer vary in purity, the manufacturer adopts a formula for his product and mixes the ingredients, adding enough filler of some harmless but useless material to bring his mixture to the desired proportions. This practice may be justified on the ground that a product of uniform composition is needed, and perhaps the physical character of the mixture may be actually improved, but it nevertheless involves a distinct economic loss in mining, preparing and moving the filler and other impurities, and eventually the cheapest fertilizer to the farmer is likely to be a preparation from which the filler and other impurities have been eliminated.

CHAPTER X

OTHER INDUSTRIAL MINERALS

G. F. Loughlin[1]

A call for high-grade graphite for use in crucibles required for making steel — Foreign and domestic sources of graphite — Domestic graphite made serviceable by better treatment and a change in methods — Future of the American graphite industry — Mica used in war and peace — Quantity and quality of domestic mica marketed — Asbestos of good quality rare — Location and output of American deposits of asbestos — Magnesite needed for use in steel-making — Utilization of domestic magnesite and sintered dolomite — Other refractory minerals — High-grade clays and good chalk rare — Possible independence of America as to clay products — Good domestic fluorspar found and utilized — American resources of sand, gravel, limestone, and other stone — Improved methods of mining and milling necessitated by the war make for American industrial independence.

Although potash and nitrates have recently attracted nation-wide attention, particularly because of their scarcity and of the urgent need for them in agriculture, several other industrial minerals that are indispensable in the military, naval, and commercial activities of the nation have received scant attention, even from those who are engaged in industries that could hardly be carried on without them. Until we were compelled greatly to increase our manufactures and to curtail our imports, on which we had been almost unconsciously depending, we did not realize the necessity of further developing our own resources of these minerals. Like the stokers on an ocean liner, who are seldom, if ever, seen by the passengers and the value of whose service is realized only

[1] United States Geological Survey.

when the supply of steam becomes deficient, these minerals are an unrecognized means of power and of progress.

When the cry arose for a greatly increased output of steel to supply our own needs and those of our allies, there was an immediate call for more crystalline graphite for use in making crucibles. Our imports of graphite from Ceylon had been reduced. Had we in our own country any considerable quantity of graphite of the proper quality for this use? More fluorspar was also needed for the steel-making industry. Where could it be found in this country? The war cut off our supply of Austrian magnesite, which our steel manufacturers had been using for lining their furnaces. What could we find to take its place? The increase in the output of electrical apparatus at once called for a corresponding increase in the supply of the very best mica. Could any large contribution to this supply be made from our own deposits? Could our deposits of asbestos help to supply the greatly increased demand for that mineral and so relieve the pressure for more Canadian asbestos? Our imports of emery, principally from the Greek island of Naxos, were stopped. Could we from our few small deposits supply the deficiency? Could we among our vast resources of stone, clay, sand, and gravel find materials that would adequately replace special products that had heretofore been imported and that would meet the new large demands made by certain of our war industries, such as the manufacture of cyanamide and the construction of concrete ships?

To all these questions we furnished more or less satisfactory answers. Most of the emergency demands were supplied from mineral deposits in the United States, but it must be admitted that the demand for a few of

the minerals most urgently needed was not so supplied. Even as to these minerals, however, we could perhaps achieve absolute independence if we should make radical changes in certain of our methods of manufacturing and mining that would increase the cost of production — changes, however, that would hardly have been justified even by the abnormal conditions caused by the late war.

Graphite (plumbago or black lead) is most commonly used as the "lead" in pencils and is thus familiar to us from the kindergarten through life. As a constituent of stove polish and as a lubricant for automobiles, bicycles, and other machines, including the pedals of pianos, it is of wide service. It is used also as an ingredient of paint, as a polish for gunpowder, in foundry facings, in compounds for loosening boiler scale, in electrotyping, and in electric apparatus. There has been no shortage of graphite for any of these uses, and if these were its only or its principal uses, it would not be considered here, but by far the greater part of the graphite consumed is used in making the crucibles required in the manufacture of steel, and this part is therefore essential in time of both peace and war.

The graphite of the tramp's bit of lead pencil and the diamond of the heiress's jewel box, though so widely separated in their social relations, are nevertheless merely differently crystallized forms of carbon, and are therefore closely akin to the most widely used mineral products, coal and petroleum, which because of their fundamental and general usefulness may be called the common laborers of the carbon race. Graphite, through its form of crystallization, has become a special industrial artisan, whereas diamond, through a different form

of crystallization, has been so ennobled that, although it is a better abrasive than any other natural or artificial mineral product, it is noted chiefly as an ornament in society.

The properties that fit graphite for its different uses are its extreme softness and smoothness (next to talc it is the softest and smoothest of all minerals); its black color or "streak;" its perfect cleavage, by which it is readily reduced to thin, flexible flakes or scales; its electric conductivity; its ability to withstand high temperatures; and its resistance to chemical corrosion. By no means all graphite deposits, however, furnish material suitable for all or for the most important of its uses.

The commercial deposits of graphite are of three kinds: veins from which crystalline graphite can be recovered in nearly pure lumps; beds or layers of a rock known as mica schist containing disseminated flakes of graphite; and beds in which graphite occurs in masses so fine-grained that its crystalline character is not apparent. The graphite of the better grade taken from deposits of the first kind is called "lump" and "chip" graphite; that taken from deposits of the second kind is called "flake" graphite. The fine material produced in the recovery of graphite of these better grades is sold as "graphite dust." The natural fine-grained variety is known to the trade as "amorphous" graphite, although under the microscope much of it is seen to be crystalline. "Amorphous" graphite is also manufactured, either from anthracite coal or from petroleum coke, in electric furnaces at Niagara Falls.

For many uses, such as foundry facings, lubricating compounds, lead pencils, dry batteries, and paints, amorphous graphite and graphite dust are satisfactory.

The country's output of both has been considerable, and relatively large imports from Mexico and smaller imports from Chosen (Korea) have left us no reason to worry, even during the war, about our supply of graphite of these kinds. We had, however, good reason to worry about our supply of crystalline graphite in the form of lumps, chips, and flakes. For lump and chip graphite we have always depended on Ceylon. The Ceylon graphite occurs in veins, which are worked by open pits and by underground mines. The workable veins range in width from two or three inches to several feet and contain masses of graphite which, when broken to free them from mineral impurities, yield the much desired lump graphite as well as the smaller chips and dust. The only deposits in our country that are at all comparable with those in Ceylon are at Dillon, Montana, at Ticonderoga, New York, and near Buck Mountain, Albermarle County, Virginia. The deposit at Dillon has been worked in recent years but has yielded only a very small proportion of the quantity of graphite we have annually consumed in making crucibles. With these exceptions the commercial deposits of crystalline graphite in the United States are beds or layers in mica schist containing from three to 10 per cent. of graphite that occurs in flakes, most of the largest ones measuring about three millimetres (one-eighth inch) in diameter, though some measure 12 millimetres or more. Nearly all these deposits are worked by open pits, and the graphite is separated from the quartz, mica, and other minerals of the rock by milling and concentration. The best grades of concentrates contain 85 to 90 per cent. of graphitic carbon, the percentage required by crucible manufacturers.

The domestic deposits of flake graphite now worked

are scattered through 12 states. In 1917 Alabama furnished about 59 per cent. of the domestic output, which represented 66 per cent. of the value. New York and Pennsylvania were second and third, respectively, and Alaska, California, and Texas furnished smaller quantities. Montana furnished some lump graphite. The total quantity of domestic crystalline graphite sold in 1917 was 5,292 short tons, more than two-thirds of which consisted of No. 1 and No. 2 flake. The imports of graphite (mostly flake) from Madagascar amounted to 4,393 short tons, and those from Ceylon (chiefly lump and chip) amounted to 24,575 short tons. Some crystalline graphite was also imported from Canada and Brazil. These figures show that the United States in 1917, as formerly, depended mainly on Ceylon for its supply of high-grade crystalline graphite.

Before the war began, the excellent quality, ample supply, and low cost of Ceylon graphite gave little encouragement to the mining of domestic crystalline graphite. Our annual production never had been more than 2,583 short tons, and in 1912 and 1913 the price of domestic graphite exceeded that of Ceylon graphite by one-tenth of a cent a pound. Soon after the outbreak of the war in 1914 the British and French Governments required certain guarantees from importers and users of Ceylon and Madagascar graphite to prevent it from falling into the possession of the enemy. The requirement, the increasing shortage of ships, the much greater demand for steel, and, after our entry into the war, the efforts of our Shipping Board to stop all unnecessary imports, helped greatly to stimulate the domestic production. The sales increased slightly in 1914, rose to 3,537 tons in 1915, and reached 5,466 tons in 1916. The price of domestic crystalline graphite rose from five cents

a pound in 1913 to 5.5 cents in 1914, 5.9 cents in 1915, 8.4 cents in 1916, and 10.3 cents in 1917. During the same period (1913-1917) the prices of Ceylon and Madagascar graphite increased more rapidly, equaling that of domestic graphite in 1914 and reaching 14.6 cents and 12.3 cents a pound, respectively, in 1917. In spite of the advantage thus gained by domestic graphite, however, the demand for it in 1917 and the first half of 1918 was small, mainly because it is different from the Ceylon graphite to which manufacturers had become accustomed. Difficulties of transportation and shortage of labor and supplies further curtailed the domestic production, which was slightly less in 1917 than in 1916.

Crucible manufacturers have preferred Ceylon to other graphite because it is sold in fairly well standardized grades and because its particles are cubical rather than flaky in form, so that it requires a smaller percentage of clay binder and makes a more durable crucible. Madagascar graphite, which consists of thicker flakes than the domestic graphite, also requires a smaller percentage of clay binder. Since the outbreak of the war, however, owing to the shortage of Ceylon graphite, a mixture of Ceylon and domestic graphite has been used by American crucible workers. In 1917 they used such mixtures containing as much as 25 per cent. of domestic graphite, and in 1918 mixtures containing as much as 35 per cent. Improvements have been made in separating the impurities from domestic graphite and in standardizing it, and producers have now established a basic grade of 85 per cent. graphitic carbon and give a bonus for higher grades. While these improvements were being made, the restrictions on the importation of graphite were extended through 1918, and it was arranged that at least 25 per cent. of domestic graphite was to be used

in crucibles and sufficient Ceylon graphite admitted to supply the remainder. These changes raised the domestic graphite industry from a rather discouraging position to a position of much promise, and near the close of the war the demand equaled or exceeded the capacity of the producers. The principal impediment to greater production was a shortage of cheap labor.

Can the successful exploitation of American graphite be continued after the war? The answer must depend upon the satisfactory use by our manufacturers and other consumers of the present mixtures of foreign and domestic graphite (75 and 25 per cent.) respectively and upon our willingness to try mixtures containing larger proportions of domestic graphite; upon further improvements in milling, whereby flakes of large average size can be recovered and a greater percentage of the product made suitable for crucibles; and upon the lowering of the cost of production. Ceylon graphite will continue in favor and will command a higher price than the domestic, but as deep mining has become necessary in Ceylon, the cost of mining there has been rising, and the output is not likely to be very much increased. The advantage given to domestic graphite by the state of mining in Ceylon, however, may be offset by a reduction in the price of Madagascar graphite, which under normal shipping conditions can be placed on the New York market at a lower price than the domestic product, and by the increasing use of electric furnaces instead of crucible furnaces in metallurgical operations.

Mica, like graphite, is far more intimately interwoven with our everyday life than many of us realize. The "isinglass" in our stove doors and in some of our lamp chimneys, the silvery substance on our wall paper, the

diaphragms in our telephones and phonographs, the spark plugs for the automobile and the goggles for its driver are made of cut or ground mica. Mica, then, is our constant companion, not only at home but in the office and on the road. In the mechanism that we use to generate or transmit electric power mica is employed as an insulator, and mica of the very best quality is especially needed in high-potential electrical apparatus, particularly magnetos and condensers. By its use in condensers for airplanes and in "windows" for gas masks it became a mineral of great utility in warfare both above and on the ground, and its use for covering wounds made it especially valuable behind the lines as well as at the front. It is also used in wireless telegraph apparatus and for windows in the conning towers of warships and submarines, where glass would be broken by heavy shocks or vibrations. It thus contributes its share to both warfare and commerce on sea and on land.

There are three kinds of mica, white (muscovite), amber (phlogopite), and black (biotite). All have found commercial use, particularly the white variety and to a considerable extent the amber; but the black variety has been used only to a small extent in ground form as a constituent of lubricants and in certain artificial ornamental stones. Ground chlorite (clinochlore), a green, soft, flaky or scaly mineral very similar to mica, is employed for dusting rubber and roofing material and for several other purposes for which ground mica also is used.

White mica may be split into very thin, elastic, transparent sheets or films which are soft enough to be scratched by the finger nail yet are able to resist very high temperatures without deterioration. It is a hydrous silicate of potassium and aluminium, and its purest varieties are free from minute inclusions of other min-

erals, particularly iron oxides and black mica, the presence of which, even in the smallest quantities, makes it unfit for use in high-potential electrical apparatus. Freedom from cracks and small cavities, or "pin holes," from which minute granules of hard, brittle minerals, generally quartz or feldspar, have dropped out, is also essential in high-potential mica. For some kinds of electrical machinery, especially for commutators made of copper and mica, amber mica is preferable to white mica, as it is more nearly of the same hardness as copper, so that the two wear down almost evenly.

Mica for high-potential electrical apparatus was in great demand during the war, but most of the domestic mica thus far produced is unsuited for use in such apparatus and the demand has been supplied mainly from India. Users admit that domestic mica that satisfies the most rigid requirements of this kind has been mined, but only in quantities so small and at intervals so long and uncertain that they can place no dependence upon it.

The scarcity of mica of the best quality appears more remarkable when we remember that mica constitutes about four per cent. of all igneous rocks, but by far the greater part of it occurs in the minute black and white flakes which give granite its speckled appearance. Commercial mica is limited to certain extremely coarse-grained veins of a rock called pegmatite, found in granite and associated crystalline rocks. Such veins are numerous in the New England and Appalachian states and in some of the mountain states of the West, particularly South Dakota, Colorado, Idaho, Utah, Arizona, and California. Most of these veins would yield mica suitable for use in grinding and for cutting into sheets of the smallest size (1½ by two inches), but veins could not be worked profitably for these products, even if the

sheets were of the finest quality. The selling price of sheet mica increases rapidly with increase in the size of the sheets, and the ability of a mica mine to produce large sheets goes far toward making it successful. Veins containing great quantities of crystals of mica that will yield sheets of the larger sizes are relatively scarce; only a small percentage of the total mica produced even from the largest veins yields sheet mica.

At the time of their origin the growing mica crystals in mica-bearing veins are likely to enclose other minerals that crystallize at about the same stage of vein formation. As pure artificial salts can form only under laboratory conditions that prevent the simultaneous growth of other salts, so pure mica can form only under natural conditions that cause the associated minerals to form either before or after but not simultaneously with it. An examination of many mica crystals show that in some veins certain stages of crystal growth took place under conditions favorable to the formation of pure mica, whereas earlier or later stages took place under conditions less favorable, so that some parts of a single crystal may be of excellent, and other parts may be of inferior, quality. Changes that take place in a vein while it is being formed or some time after may injure the quality of an originally excellent crystal of mica. Shearing or compression stresses in the earth's crust may form in a mica crystal parallel cracks or "rulings" which are so close together that the mica is suitable only for grinding into powder, or the crystal may become so warped or squeezed among other minerals that sheets of sufficient size and thinness for even ordinary demands cannot be cut from it. Water percolating downward from the surface may leach iron from minerals in the surrounding rocks and deposit it as brown or red oxide

along the cleavage planes of the mica, not only ruining it for electrical work but decreasing its transparency and thus barring it from other uses. Mechanical deformation connected with the growth of mountains has been effective, though not uniformly, throughout the mica regions in the eastern part of the country and doubtless to some extent in the West. Iron staining due to weathering has been most effective in the Southeastern and Southwestern States. Even in regions that have undergone considerable deformation as a whole, however, areas may be found in which the mica largely escaped injury. Of the veins in such favored areas some may be found in which the mica crystallized under favorable conditions, but the fact that in spite of the urgent demand caused by the war only a negligible quantity of domestic mica of the best quality has been marketed and that the production of domestic sheet mica for all purposes has only a little more than held its own appears to show that such favored veins are indeed exceptional.

Although about 96 per cent. of the ground mica consumed in this country is of domestic origin, the proportion of the sheet mica consumed for all purposes represented by domestic production during the 18-year period 1900-1917 averaged about 38.5 per cent. From 1914 to 1917 inclusive, it ranged from 40 to 42 per cent. The total quantity of domestic sheet mica sold in 1917 was 1,216,816 pounds, valued at $708,381, but no information is available to show what proportion of it was of good quality, slightly stained, or heavily stained, or what proportion was in sheets above a certain size. This mica was mined mainly in North Carolina and New Hampshire, but small quantities were mined in Virginia, South Dakota, Georgia, and Alabama.

During the same year 656,391 pounds of uncut sheet

mica, valued at $414,823, and an unstated quantity of cut or trimmed mica, valued at $1,014,181, were imported. The value of the imports of mica in 1917 was more than double that in 1914 or 1915 and much greater than that in earlier years. India and Canada are the principal sources of our imports, Canada furnishing mainly amber mica (phlogopite). Brazil and Argentina furnish small quantities, and in 1917 Guatemala and Mexico each contributed some — less than one per cent. of the quantity imported. The mica imported, unlike the domestic mica, consists largely of clear sheets of good quality. India has supplied practically all the mica used in high-potential electrical work. The mica in Brazil is said to be similar to that in India, but because of difficulties as to labor and transportation the Brazilian deposits have not been extensively developed. The total quantity of foreign mica used in this country, even in war time, has not been large enough to occupy much shipping space, but the users nevertheless at times had some difficulty in obtaining sufficient supplies of it to enable them to fulfill their Government contracts.

Even under the conditions produced by the war the domestic producers, whether in the East or in the West, have not succeeded in competing with Indian mica. The price paid for selected Indian mica is lower than that which would be asked for similarly selected domestic mica. If all imports of high-grade mica were discontinued, we could procure a steady supply of domestic mica that would meet the most exacting demands only by changing our methods of sorting and marketing. At present it is the producer's practice to cut the largest possible rectanguler sheet from a piece of rough mica. A part of this sheet may be of the very best quality, but the producer can obtain a higher price for a single large

sheet than for two or three smaller sheets that are graded according to quality. Some users of sheet mica call for shipments made up of sheets of a certain size and of a quality fixed by certain rigid demands, yet at a price no greater than producers can obtain for sheets of the same size without so strict a guarantee of quality. Were these trade customs so modified that mica of the highest quality and of specified size could be cut and sold at a price that would return a reasonable profit to the producer, even at the sacrifice of larger sheets, the supply of domestic mica that would meet the most exacting requirements could undoubtedly be much increased; but it is far from certain, even under these conditions, that the domestic demand for high-grade mica could be supplied entirely from domestic deposits. For low-potential and non-electrical uses domestic mica can meet all requirements, although much imported mica is employed for these uses, but to meet the exacting requirements of high-potential apparatus the United States must continue to depend upon foreign mica, principally that mined in India.

A third mineral of which we have an inadequate supply, but the value of which we are learning to appreciate, is asbestos. The word asbestos has become familiar to us, for the mineral has long been used as a heat insulator in kitchen utensils and around furnaces, boilers, and steam pipes and as a means of protection in fireproof theatre curtains; but how many of us have stopped to consider whether it is really a mineral and where we obtain our supply of it? The term "asbestos" is applied to certain minerals — or rather to a group of minerals — that have a strongly marked fibrous structure. The same minerals occur also in massive non-fibrous varieties, each

known by a distinctive name. The most valuable asbestos is chrysotile, a fibrous, silky, light-colored variety of serpentine, the green mineral that gives the distinctive color to verde antique marble. The asbestiform variety of anthophyllite, a member of the amphibole group of minerals, is more brittle than chrysotile. Blue asbestos, or crocidolite, is a flexible fibrous variety of another kind of amphibole. For some uses anthophyllite and crocidolite are superior in some respects to chrysotile. Thus, anthophyllite offers greater resistance to attack by heat and acid, and is the only kind of asbestos used in the chemical laboratory for filters. When mixed with refractory clay in suitable proportions, it is also employed for making the stiff asbestos mats and boards used on and around stoves. Crocidolite, imported from South Africa, is used in electric welding, because of its ready fusibility. None of these varieties, however, possesses so flexible or so long a fibre as chrysotile. It is chrysotile that is used in theatre curtains and other flexible cloth-like products and that is particularly in demand. More of this variety of asbestos is sold than of all the other varieties combined.

Our supply of the more brittle varieties of asbestos has been equal to the demand, but our supply of chrysotile has been very deficient and most of the domestic chrysotile is inferior to that which is imported. Chrysotile forms veins, most of them in massive serpentine rock (altered peridotite), ranging in width from the smallest fraction of an inch to five or six inches. The fibres commonly lie crosswise in the vein or at right angles to its sides, and the wider the vein the longer and the more valuable the fibre; but most of the commercial fibre does not exceed two inches in length. In places where a disturbance of the earth's crust has caused the

walls of the vein to slip or move in opposite directions along the vein, long fibrous masses, called slip fibre, have been formed, the fibres lying parallel to the walls; but slip fibre is not so flexible as the higher grades of cross fibre. Not all cross fibre, however, is of great flexibility; all gradations may be found, from the "wooliest" fibre to hard, brittle rock in which the only feature suggesting asbestos is a transverse coarsely fibrous texture.

The Canadian deposits of asbestos just north of Vermont are not only the most extensive yet found, but yield a greater proportion of the longest and most flexible fibre. These deposits have furnished fibre so excellent and are so close at hand that we had but little incentive to work our own deposits until threatened embargoes and restrictions placed on our manufacturers because of the war caused us to give more attention to the domestic supplies. Deposits of asbestos are found at scattered localities in New England and in the Piedmont region of the eastern states, in Wyoming, Idaho, Arizona, and California. Deposits in northern Vermont, Wyoming, and California have furnished some chrysotile asbestos, but the results of the work done on the domestic deposits were not encouraging until veins were recently discovered and mined near Globe and the Roosevelt Reservoir, in Arizona. Georgia has furnished the greatest supply of amphibole asbestos.

The Arizona asbestos veins are unusual in that they are in serpentinized limestone, not in peridotite. As a great thickness of other rocks lies over the limestone and prevents a study of the extent of the deposits except along canyon walls, no close estimate of the reserves of the district has been attempted. The producing capacity of the present operators may be as much as 1,000 tons a year. The quality of the asbestos as regards flexi-

bility and length of fibre is fair to excellent and the proportion of its spinning fibre to the lower grades is much greater than that in the Canadian deposits. It contains less iron than the Canadian asbestos and is accordingly better adapted to use in electrical apparatus. A considerable part of the Arizona asbestos, like that of many other deposits, is "harsh"; it does not yield fibres so soft, strong, and flexible as those in the best grade. This harshness is due in part to films of calcium carbonate that surround the fibres, and is largely eliminated in the process of milling.

The encouraging market for Arizona asbestos has been due largely to the war, for the demand of war industries exceeded the available supply of Canadian asbestcs. As the Arizona deposits are far from the markets, they would be at a great disadvantage in a time of lessened demand, but the excellent quality of the high-grade fibre and the fact that some of the Arizona producers control plants that manufacture asbestos products and have successfully developed processes for milling the lower grades should offset this disadvantage. It is expected that these producers will attempt to specialize in the manufacture of electrical supplies and other products for which Arizona asbestos is particularly suited. If this attempt is successful they may gain not only the domestic market for these products but extensive foreign markets as well.

A most striking industrial change caused by the war has been the recognition, development, and utilization of our resources of magnesite (magnesium carbonate), our supply of which had been obtained mainly from Austria until the outbreak of the war in 1914. Some magnesite has been used in the manufacture of paper pulp (sulphite

process) and of heat-insulating materials, particularly boiler and pipe coverings, as well as of cements and artificial stone and of magnesia salts for medicinal and other uses, but by far the greater part of the output has been made into refractory products (calcined magnesite and magnesite brick) for use largely in open-hearth steel furnaces. When it is calcined, magnesite is transformed into magnesium oxide (magnesia), which can remain a long time in contact with air and water without change in character. It can also resist very high temperatures without fusion, and has therefore been in favor as refractory material.

For a long time California was the only state known to contain extensive deposits of magnesite, but these deposits were so remote from the larger steel-manufacturing districts and most of the magnesite was so inferior to Austrian magnesite for making refractory products that it was utilized almost exclusively for other purposes. Austrian magnesite contains a small percentage of iron, which fuses at high temperatures, knitting the calcined product together and lessening its tendency to disintegrate after repeated heating and cooling.

The cutting off of the Austrian supply immediately showed that magnesite was a scarce and much needed war mineral. The deposits in California began to be drawn upon as the only source large enough to supply the demand, and our urgent need of the mineral made possible both the use of magnesite deficient in iron and the costly transcontinental haul by rail. At the same time, however, someone recollected that chemical analyses of certain supposed marbles in the state of Washington, the exploitation of which had been a failure, showed a very high content of magnesium carbonate — in other words, that the rocks were not ordinary marble (crystal-

line limestone) but magnesite. The failure to recognize their true character earlier was evidently due to their close resemblance to granular marble and their striking difference from the pure-white, dense or grainless magnesite that was so well known in California. Another difference was that, whereas most of the exploited deposits in California lay in distinct veins of comparatively small dimensions, those in Washington formed extensive ledges, identical to the casual observer with thick and extensive beds of limestone or marble.

Investigation proved that the Washington deposits were practically inexhaustible, and analyses of samples taken from newly opened prospects indicated that their chemical composition was very similar to that of Austrian magnesite. As the Washington deposits were worked more extensively and deeply, however, it was found that their iron content did not average so high as had been expected, and a process was devised for adding iron to the calcined product.

The work of mining these deposits was begun late in 1916, and in that year they yielded 715 tons. In 1917, 105,175 tons were sold from deposits in Washington and 211,663 tons from those in California. In 1918, however, the production declined markedly, a fact which appears to indicate that magnesite is not so indispensable a war mineral as has been supposed. When a shortage of magnesite was threatened in 1914, a search for a substitute began, and dolomite, a calcium-magnesium carbonate, was naturally considered. Dolomite, like limestone, occurs in extensive beds and is quarried in large quantities for burning into lime. When lime made from dolomite is exposed to the air at ordinary temperature and pressure, the calcium oxide it contains hydrates, or slakes, but the magnesium oxide is almost

or quite unaffected. The problem of making from dolomite a satisfactory substitute for magnesite therefore lay in preventing its calcium oxide from slaking. Experiments showed that by calcining the rock at an unusually high temperature or by recalcining the burned product to sinter the particles of calcium oxide together slaking could be prevented, or at least greatly retarded. The product was not uniform, however, and an improvement in the process was made by mixing the burned rock with slag or a suitable clay and recalcining, as the slag or clay melted and spread over the particles of calcined rock so as to form an impervious coating. This improved process has been generally successful, and the product, though very small in 1914, has increased each year. In 1917 about 679,000 tons of dolomite, equivalent to about 340,000 tons of finished product, was quarried for use as refractory material. This quantity considerably exceeded the quantity of crude and calcined magnesite imported annually before and during the war.

The process of manufacturing refractory material from dolomite is obviously more complicated and more expensive than the simple calcination of magnesite, but under the stimulation of high prices the industry has successfully passed through the costly experimental stages. The proximity of the raw materials to steel-making plants is an advantage that may more than offset any greater cost of the product compared with that of domestic magnesite, which must be transported from the Pacific Coast states, or with that of Austrian magnesite, which, though low priced when landed at Atlantic coast ports, must stand the cost of transportation across the Appalachian Mountains. Some of the more northern markets may continue to call for magnesite from Canada, but others will doubtless continue to depend on dead-

burned or sintered dolomite, so that the manufacture of this product may survive the war as a permanent industry and lead to the exclusion of Austrian magnesite, or at least to a great reduction in its importation.

Besides graphite and magnesite other refractory materials, particularly high-grade clays, ganister (quartzite), bauxite, and chromite, have been of great value in war industries, but the United States is abundantly supplied with all these materials except chromite, which is considered elsewhere.[2] These have all found greatly increased use during the war, particularly silica brick made from ganister, production of which rose from a value of $288,244 in 1914 to $1,350,798 in 1917, when 1,295,851 tons were sold. This quantity was 50 per cent. greater than that sold in 1916, which in turn was 50 per cent. greater than that sold in 1915. This remarkable increase in the use of silica brick, proportionately greater than the growth of the industries in which it is employed, suggests that it has been used successfully as a substitute for certain other refractories that are less readily obtained.

Another refractory, now in the experimental stage of development, is zirconia. Zirconia occurs in nature as the mineral baddeleyite, which can be imported in considerable quantities from Brazil but which has not been produced in the United States. Owing to the comparative cheapness of the refractories already considered, however, zirconia will probably not be used as a refractory except in a few industries. As a constituent of zirconia steel, particularly adapted for making armor plate and armor-piercing projectiles, zirconia has been in some demand. The supply needed for this use

[2] Chapter VIII.

can be derived from the silicate mineral zircon, as well as from baddeleyite. Because of the war-time condition of shipping the domestic deposits of zircon aroused considerable interest, but the small quantity of zircon heretofore used annually has been obtained more cheaply from Brazil than it could have been at home. Should the prices after the war be good, zircon in quantity sufficient to supply the demands could doubtless be recovered from certain zircon sands, particularly those in the South, and from some of the mill tailings in western mining districts. The same general statement may be made concerning monazite and other uncommon minerals, small quantities of which are used annually.

Before the subject of refractories is dismissed, a word should be said about clay, which is used as a principal or accessory constituent in so many products that a leading manufacturing country must possess a great variety of clay resources in order to maintain industrial independence. Before the war domestic clays were used in making many refractory products but not in making graphite crucibles, for which a German clay was used. As soon as it became impossible to obtain the German clay, the manufacturers of these crucibles, in which the clay is used as a binder, were compelled to search quickly for a suitable domestic clay. The clays that were most like the German clay were tried, and after continued experimentation with the most promising of them a clay was found that would make crucibles as durable as those containing German clay. It may safely be stated, therefore, that the United States is now independent as regards refractory clays.

In high-grade clays required for certain other uses, however, our resources have apparently been deficient,

a fact that was at once realized when, in order to conserve shipping, it was proposed to curtail the imports of clays. Immediately many of our manufacturers, especially of paper, pottery, and sanitary and electrical porcelain, declared that without imported English clays they could not continue in business. Attempts made by some of them to use domestic clay in view of a foreseen shortage of English clay had been only in part successful. The difficulty here, as in certain other branches of industry, was evidently due to a combination of causes. The domestic clay miners had not been using proper care either in mining or in refining their clay to insure a uniform product, and the manufacturers, long accustomed to using English clays, were reluctant to make experiments and to readjust their processes to obtain the best results from properly prepared domestic clay. However, there is an endless variety of clays, even among those that the mineralogist might call similar, and a manufacturer cannot successfully substitute one high-grade clay for another without long trial and experience.

To relieve the stress for high-grade clay a committee was formed to coöperate with manufacturers and with certain Federal and state bureaus in the study of the clay and clay-products industries and has made satisfactory progress. In the meantime the necessity of increasing the number of trans-Atlantic trips led steamship companies to refuse cargoes of clay and chalk, bulky materials the loading and unloading of which greatly detained a vessel in port, so that manufacturers found it more than ever necessary either to employ substitutes or to adjust their processes to the use of domestic clays. The mineral talc, with which we are adequately supplied, has proved equal to imported clay for filling

paper and, according to some authorities, for coating it. Some domestic clays have proved satisfactory for making electric porcelain, and a feature of the pottery industry in 1917 was the establishment in Tennessee of a pottery that used only domestic clay. Much progress has also been made in the manufacture from domestic clay of the porcelain used in chemical laboratories, though this work has not been done in a commercial way. In 1917 a factory in Ohio successfully began to make bisque dolls' heads from domestic clay, an industry that had been monopolized by Germany.

The prospect that our country can become absolutely independent in its clay-product industries is therefore reasonably bright. During the period of transition from the use of familiar imported clays to that of domestic clays which are at present imperfectly prepared and imperfectly understood, the dishes we buy may be somewhat inferior to those we have used, but this is only an insignificant detail in the great crisis through which we have passed and should call for no complaint from those who understand the conditions. The White House set of State china acquired under the Wilson Administration is appropriately American in material and handicraft, and the specimens reserved for exhibition will form a noteworthy addition to the collection that illustrates the various styles of china used by our Presidents since the days of Washington.

Whether this country shall actually become wholly independent of imported clays must depend upon the progress made before the conditions of ocean shipping again become normal and on the comparative costs of domestic and foreign clays. Both raw clays and manufactured clay products will probably be imported after the war, particularly from England and Japan, but more

of the manufactured products will be classed as pure luxuries than formerly, and the utilization of domestic clays has now progressed so far that should the necessity ever arise, the United States could no doubt become quite independent in its clay industries.

The situation as to chalk is similar to that as to clay. We have used some domestic chalk instead of limestone in the manufacture of Portland cement, but for levigated chalk, or whiting, which we use in large quantities, we have depended upon chalk imported from England and France. When the question of curtailing the imports of chalk was raised, the manufacturers maintained that the quantity and quality of their products, particularly paint, putty, and rubber goods for filling war contracts, would be lowered by the stoppage of imports, and that although our deposits of chalk were large, no domestic chalk of satisfactory quality had yet been discovered. It is doubtful whether the domestic deposits have been so thoroughly prospected as to warrant the statement that there are no deposits of high-grade chalk in this country, but our present knowledge indicates that they are at least comparatively scarce. The most promising deposits, furthermore, lie as far west as Nebraska, Kansas, Arkansas, and Texas, whereas most of the large manufacturing plants that use whiting are along or near the Atlantic seaboard.

But although natural domestic chalk may be inferior to foreign chalk, promising substitutes have been made by grinding white marble or limestone to an impalpable powder. The precipitated calcium carbonate obtained as a by-product in the manufacture of basic magnesium carbonate (magnesia alba) from dolomite is also worthy of consideration as a substitute, provided it can be

economically dried. A mixture of this material and marble dust has also been suggested as a product most closely duplicating the whiting made from natural chalk. While imported chalk was available, manufacturers maintained that these substitutes were unsatisfactory, but the producers of the substitutes are reporting shipments to rubber and paint manufacturers, and few, if any, inquiries have been heard regarding a supply of natural chalk to take the place of English chalk. Some manufacturers of the substitutes maintain that they are now successfully competing with English chalk and expect that they can continue to do so after conditions again become normal.

Another mineral that is comparatively scarce is fluorspar (fluorite, calcium fluorite), which is used as a flux in making steel and other metals and in the ceramic and chemical industries. Limestone also can be used as a flux, but fluorspar is so much better that steel manufacturers have been willing to pay high prices for it, the price f. o. b. mines, after decreasing from $5.87 in 1913 to $4.89 in 1914, advancing to $30 and, for a short time, to $40 a ton in 1918. The quantity of fluorspar produced increased from 115,580 tons in 1913 to 218,828 tons in 1917, and producers of fluorspar 85 per cent. pure found a ready market for their product. The production in 1918, however, was no greater than that in 1917, the failure to increase being attributed to shortage of labor and supplies.

During the last few years fluorspar has been used as an ingredient of raw Portland-cement mixtures to increase the recovery of potash as a by-product. Domestic fluorspar has recently supplanted imported material for use in lenses in certain kinds of optical instruments, in

which its low refractive and dispersive powers make it particularly desirable. To be suitable for optical work fluorspar must be in pieces at least an inch long and half an inch thick, absolutely transparent, nearly or quite colorless, and free from flaws, such as partly opened cleavage cracks and striae. Such fluorspar is very rare, but persistent search has discovered material which by careful sorting can furnish sufficient to supply the small demand.

Fluorspar occurs mostly in veins or closely related deposits, usually in translucent purple, green, or colorless crystalline masses. It is not hard, and it cleaves easily in four directions, thereby easily breaking away from the calcite and quartz that are commonly associated with it. It is also somewhat heavier than these minerals, and these properties together aid in its concentration to the necessary standard of purity.

The largest and most productive deposits of fluorspar are in southern Illinois and northern Kentucky, where it is associated with sulphides of lead and zinc. Other deposits that have supplied the market are in Arizona, Colorado, New Mexico, New Hampshire, and Tennessee, and in these deposits also the fluorspar is associated with metalliferous minerals. In normal times the western deposits supplied only the comparatively small western markets, but the war demand warranted the transportation of western fluorspar to eastern markets. Fluorspar is widely distributed through the western metalliferous mining states, but most of the deposits are too far from railroads, too small, and of too low grade to be worked profitably even in the recent abnormal times, although they could supply considerable fluorspar if extreme necessity demanded it. Our war needs for fluorite were thus met mainly from our home resources, and so long

as prices remained sufficiently high, prospecting and development kept the supply apace with the demand.

In the rapid development of inventions stimulated by war, new requirements have arisen for considerable quantities of unusual materials, as, for example, five tons of quartz crystals.

Our discovery and utilization of some of the minerals here considered have necessitated beneficial changes in practice that will help to make us industrially independent. Our improvements in mining and milling graphite and changes in our methods of making crucibles, as well as the increasing use of the electric furnace, are making us less and less dependent upon foreign supplies of that mineral. As regards mica and asbestos, our output of which has also been deficient, our imports, though curtailed, have been obtained so readily that we have not fully learned the extent to which we could be independent. We must make great changes of practice and habit in the preparation, purchase, and price of mica before we can advance appreciably toward independence in this respect, but if necessity were sufficiently urgent, could we not do so?

Our supplies of some of the less well known minerals to which our attention has been forcibly brought by the war have been thus briefly discussed, but the discussion would not be complete if it included no mention of certain well-known, abundant, and widely distributed mineral and rock products which have been indispensable to our war activities. Limestone and lime are familiar to everyone, but how many know that these common, everyday products, besides supplying the needs of the building trades and agriculture, are essential to more than 100 chemical and manufacturing industries? A

prominent chemist has aptly said that limestone and lime are the complement of sulphuric acid in the chemical industries. More than 96,000,000 tons of limestone and three and one-half to four million tons of burned lime have been consumed annually in the United States in recent years, but, though the demand may cause the exhaustion of a quarry here and there, this quantity is but an insignificant fraction of our resources. Although many industries require limestone of only ordinary grade, others require exceptionally pure stone. The new cyanamide plants, for example, daily require 500 tons of 97 per cent. pure stone, yet even these requirements have been fully met. In spite of our widely and conveniently distributed and inexhaustible deposits of limestone, however, specially prepared brands of lime to supply small demands were obtained only from abroad until the outbreak of the war. This lime was imported merely because neither consumers nor producers had ever stopped to consider whether domestic lime was not fully as good, and when our imports were cut off or curtailed, it took little time to provide a satisfactory domestic substitute.

Crushed stone, sand, and gravel, each produced in millions of tons annually from inexhaustible reserves, have been of prime importance in the construction of roads and concrete buildings for military use, and would be even far more essential if the battlefields were on our own soil. It is said that in France, next to the transportation of troops and ammunition, the transportation of crushed stone had priority over practically everything else. Special varieties of domestic stone that have hitherto been of no value except for making crushed stone, rubble, or riprap have found special uses to meet war emergencies. A porous variety of common trap

rock (basalt), formerly imported from Germany for use in paper-making machinery, is now furnished by two producers in Oregon and Washington. Basalt is widely distributed in the Far West, and if the demand should become greater, rock suitable for this purpose could undoubtedly be supplied from a number of places. An extremely porous basalt that occurs in volcanic cinder cones in certain parts of the West has recently been found to give excellent results as a light-weight aggregate in concrete for ships, and plans for utilizing it in making concrete have been under way; but a process has now been perfected for making a light-weight burned clay that gives as good results as the basalt, and as suitable clay deposits are more widely distributed, the burned clay will doubtless be preferred.

Sand, like lime, is abundant and cheap, yet certain kinds of sand required for making material of exceptional quality for special war needs are hard to find. For the manufacture of optical glass, formerly imported from Germany, sand containing not over 0.015 per cent. of iron oxide was required, and after some search such a sand was found. The search also brought to light other sand which, after a moderate amount of washing or electro-magetic separation, would be satisfactory for use in making optical glass.[8] Domestic sands suitable for use as moulding sand in casting brass and bronze have also been found to meet the demand formerly supplied by French sands.

Certain domestic deposits of gravel are now supplying grinding pebbles suitable for use in tube mills, to replace flint pebbles formerly imported from France and

[8] The development of the chemical- and optical-glass industries in the United States during the war is more fully discussed in this series by W. S. Culbertson, *Commercial Policy in War Time and After.*

Denmark. Quartzite has been successfully employed instead of flint or chert blocks, which were formerly imported from these countries for tube-mill linings.

Thus it has taken a great world war to awaken in us a recognition of the vastness and the almost endless variety of our mineral resources. The statistics of the world's mineral production show that the United States leads all other countries in its output of many products that are of primary domestic as well as international value, and that it possesses large resources of many that are of secondary value. When we consider the magnitude and the variety of our industries and the raw materials that are essential to them, we at once realize that our abundant and diverse resources of minerals of secondary value are necessarily conjoined with our resources of those of primary value to form the foundation of our general industrial supremacy. The production of some of these necessary secondary materials, the value of which we have just learned to appreciate, should be continued now the war is over, but it will be good national economy to suspend the production of others and resume importation; yet our temporary production and utilization of these others is a guaranty that, should an excessive increase in the prices of the imported materials or other unforeseen changes threaten to impede or jeopardize any part of our industrial welfare, our own raw materials lie ready at hand.

CHAPTER XI

THE POSITION OF THE UNITED STATES AMONG THE NATIONS

JOSEPH B. UMPLEBY[1]

Endowment in mineral wealth — Interdependence of nations for minerals and related supplies — Importance of mineral products in international trade — Influence on the seat of empire — Distribution of the world's mineral production — Distribution of reserves of coal, iron, copper, and other metals; petroleum, fertilizer minerals, precious metals — The United States the great center of world industry.

The United States is more richly endowed with mineral wealth than any other country. Before marshaling the facts that warrant this statement, let us try to realize its full significance, and to appreciate the importance of mineral supplies in the economy and the industrial development of a nation.

Owing to the peculiar geographic localization of mineral deposits, no country is self-sufficient in its supply of all minerals. In this respect mineral supplies are almost unique among raw materials; most countries possess agricultural lands, and much of the earth's surface is forested. It is for this reason that mineral commodities enter so largely into international trade, and, assuming a food supply, we may say that modern industry is more fully dependent upon minerals than upon the commodities of any other natural group. History shows that the course of conquest and the seat of empire have been determined in large part by the distribution of mineral deposits, and there is abundant reason for believing that in the coming peaceful conquest of the

[1] United States Geological Survey.

world mineral distribution will in much larger degree determine industrial supremacy.

The recent world crisis has thrown into strong relief the extent to which the industries of any country are interlaced with those of other countries. Almost immediately on the outbreak of the war, the mineral industry of the United States, 3,000 miles from the storm center, found itself confronted by an over-production of iron and copper and a marked shortage of other metals, such as chromium, mercury, and manganese. In Great Britain the coal output was threatened because mine timbers could no longer be obtained from Baltic ports. With the smelters of Germany and Belgian beyond the battle line, Australia had no market for her large output of zinc and lead concentrates. The principal source of potassium cyanide, the chemical so essential in winning gold from most of its ores, was cut off from South Africa and other gold-producing centers. Many of these and other similar causes of embarrassment were, however, temporary, and were soon remedied by readjusting lines of international trade; but others are inherent in the distribution of mineral deposits. The world has been dependent upon Chile for cheap nitrates; upon Germany for potash; upon Russia, India, and Brazil for manganese; upon Russia and Colombia for platinum; upon Ceylon and Madagascar for chystalline graphite; and upon a relatively few localities for tin, nickel, chromite, antimony, sulphur, phosphate, aluminum, mercury, and sheet mica. Other mineral deposits, such as iron, coal, copper, lead, zinc, petroleum, and pyrite, are more widely distributed, but even in these common minerals many countries are notably deficient.

But there is another factor, less generally recognized but no less effective, that makes for interdependence of

nations in regard to mineral supplies. Many a metal owes its greatest usefulness to some other mineral which is either desirable to give peculiar qualities to a manufactured product or is absolutely needed to separate the metal from its ores. Coke is essential in smelting iron, and in its best form it can be made only from coal that has peculiar properties, and such coal occurs in comparatively few places. The varieties of steel now demanded by industry cannot be made from iron except by adding to it manganese, nickel, tungsten, or some other metal or an alloy. If brass is to be made, zinc as well as copper is needed. To win gold from most of its ores, mercury or cyanide is essential. The makers of sulphuric acid are largely users of platinum, and the makers of explosives and fertilizer are dependent upon sulphuric acid.

Many countries are almost without mineral wealth; some are well supplied with a few of the essential minerals; but not one is rich in everything demanded by modern industry. This localization of mineral deposits leads to a very practical interdependence of nations and to relations which need to be clearly recognized by anyone who is dealing with international questions.

The two great natural endowments of a nation, wealth of soil and wealth of mineral, are not fully comparable, because one is a continuing, and the other a diminishing, asset. Land properly used continues to yield crops from one season and one generation to another, whereas minerals once taken from the ground are never replaced. Furthermore, lands suitable for agriculture are more widely and more evenly distributed than mineral deposits. The secret of continued mineral production lies in finding new deposits, in working the lower-grade portions of old deposits, and in using over again metal

already manufactured. The history of mining shows that the output of new mines has supplemented and replaced that of old ones to so great an extent as to provide fully for a world consumption increasing almost in geometric progression. But mineral production cannot keep up with the increasing demand much longer. An enormous amount of information has been published concerning the mineral supplies of the world, and if this could be supplemented by the wealth of data in the files of engineers and mining exploration companies, it could be used to determine, with fair approximation to the truth, the order of magnitude of the world's commercial mineral reserves. Sufficient data are available, however, to justify the warning that the production of several essential mineral commodities, though increasing annually, cannot keep pace for many decades with the rapidly increasing industrial expansion. Sixty-five years ago there were 330 mines producing lead in the British Empire; in 1913 there were only 55. Nevertheless, we need not fear that the growth of industry will soon be greatly retarded by a dearth of raw materials. Inventive genius and applied science will doubtless find substitutes not now thought of; the utilization of lower-grade ores multiplies mineral reserves tremendously; and the scrap-metal industry, already growing rapidly, will be an increasing source of supply as more metal is worked up. Furthermore, the slag piles and tailings ponds of yesterday are mines of to-day.

The fact that mineral wealth is gradually becoming exhausted suggests its conservation either by decreased production or by the fullest utilization. In the interest of a nation the fullest utilization is the wiser course, and this implies complete preparation for consumption, so that the exports may involve largely the renewable

asset, labor, rather than the vanishing asset, raw material. Exporting copper and iron in unmanufactured form is poor business for the nation compared with exporting electrical supplies and machinery made from copper and iron. Raw materials should be used not so much to create a trade balance as to give profitable employment to the greatest number at home. Germany built up an immense industry on the mineral resources of other nations. One-half as much zinc as Great Britain imported for consumption passed her ports in the form of ore from Australia going to the smelters of Germany. In permitting this sale of raw material was not the British Empire selling her birthright? Indeed, have not we of the United States been doing much the same thing in exporting to foreign countries large amounts of copper and iron that had passed only the first stage of manufacture?

The importance of mineral commodities in international trade may also be considered with respect to the part they contribute to the total. No data have been published to show this general relation, but an examination of official statistics indicates that, for example, about 28 per cent. by value of Germany's total foreign trade before the war was in mineral commodities, manufactured and raw. In the foreign trade of Russia it was 22 per cent., and in that of the United States it was about 33 per cent. If measured by tonnage, the percentage would almost certainly be even higher; in the United States mineral commodities form two-thirds of the total freight burden.

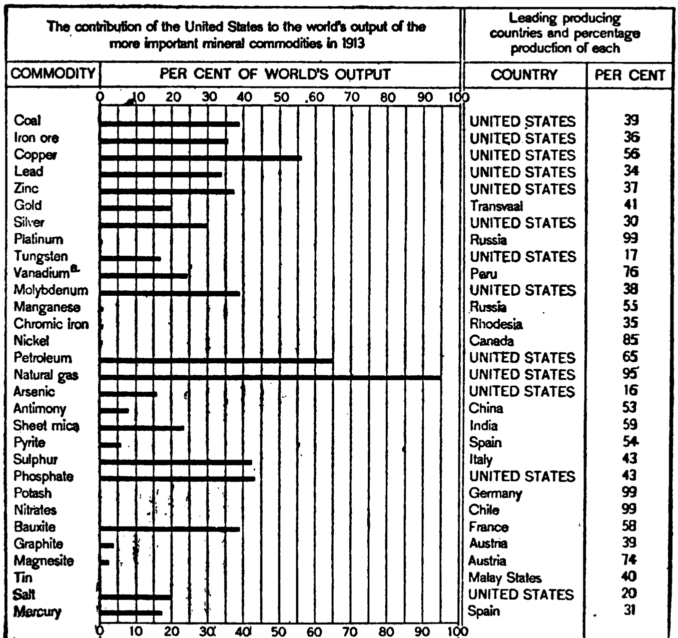
The influence of mineral supplies on the seat of empire in historic times has been admirably presented in a group of essays by Brooks Adams, entitled *The New Empire.* His general discussion revolves about the

conception that the distribution of mineral deposits "helps to explain the forces which have moved the seat of empire," and that geography largely explains "the obstacles which have fixed its course by determining the path of least resistance." Furthermore, "to procure ore men have wandered far and wide, and thus while the introduction of metal introduced a more rapid concentration at the heart of the civilized mass, it caused a proportionate expansion at the circumference." He concludes that "all experience has demonstrated that the center of mineral production is likely also to be the seat of empire; . . . at all events, no region can long retain an ascendancy without an adequate supply of the useful metals and coal."

Empire still means industry and commerce, and the motives for these today are like the motives of yesterday. As the quest for food was the stimulus of early civilization, so the quest for better food and for more of the comforts of life is the stimulus of our own industrial expansion, but the modern life is immeasurably the more strenuous. The Argonauts sailed the seas for gold, but their efforts were feeble compared with those exerted in the present search for iron and for others of the "baser" metals that are now so essential to human welfare.

The problem of finding an adequate supply of properly trained labor will always confront those who are developing new industries. In a sense the most mobile of commodities, labor is in many ways the most difficult to move. But with millions of men dragged out of their provincialism by the exigencies of the late war, it seems that labor of all classes will be more mobile in the future than ever before. This can mean only that in the immediate future the influence of the distribution

of raw materials on the seat of industrial empire will be far greater than at any time in the past, for it must be accepted as a principle that over a long period "one nation can gain from another only by cheaper produc-



[a] The figures are for 1912, as the mines of Peru were temporarily closed in 1913

FIGURE 14. CONTRIBUTION OF THE UNITED STATES TO THE WORLD'S OUTPUT OF THE MORE IMPORTANT MINERAL COMMODITIES IN 1913 AND PERCENTAGE OF EACH COMMODITY CONTRIBUTED BY THE LEADING PRODUCING COUNTRY

tion," and with sufficient mobility of labor there is no element in cheap production so fundamental as large supplies of raw material.

The preponderance of the annual contribution of the United States to the world's mineral output indicates

fairly well the magnitude of our mineral reserves compared with those of the rest of the world, because this country is still in the development stage, and large production of most mineral commodities implies expensive installation that would be warranted only by great reserves of ore.

In 1913, the latest normal year, this country held first place in the production of 13 out of the 30 most important mineral commodities, held second place in four, and contributed five per cent. or more to the world's output in four others. The preëminence of the United States becomes still more notable when its contributions are compared with those of other countries. Russia, Austria, and Spain each ranked first in the production of two of the 30 commodities and second in one; Germany and France, first in one and second in one; Great Britain second in two; and Italy, Chile, Rhodesia, South Africa, China, Canada, Peru, the Federated Malay States, and India, first in one. The percentage contributed by each country holding first place and the contribution of the United States to the production of each commodity are shown in the accompanying diagram (Figure 14).

The position of individual countries in the mineral industry of the world is more truly shown by reducing all commodities to value as a common denominator before making comparisons. If the world output of the 30 commodities listed in this diagram be multiplied by average United States prices for that year, it is found that their combined value amounted to about 4,575 million dollars. Of this amount the United States contributed over 36 per cent., whereas Germany contributed less than 15 per cent., the United Kingdom, 10.5 per cent., and no other country in excess of five per cent.

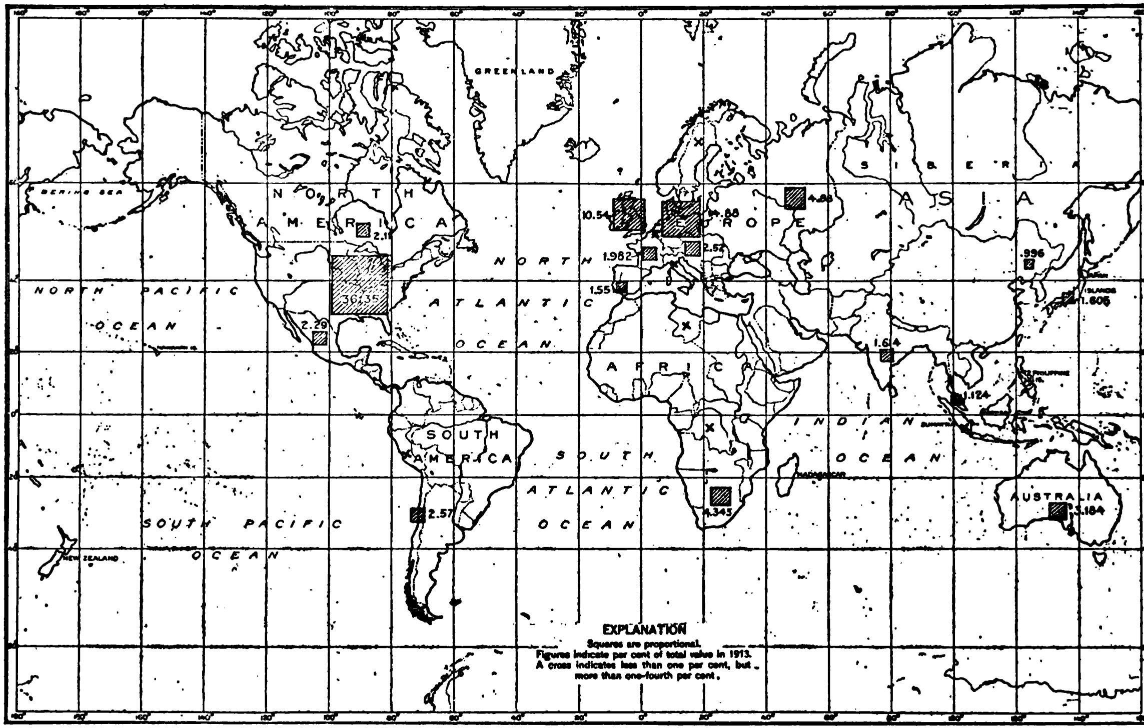


FIGURE 15. DISTRIBUTION OF THE WORLD'S OUTPUT OF 30 MINERAL COMMODITIES IN 1913, BY VALUE BASED ON AVERAGE PRICES IN THE UNITED STATES

These and other data are shown graphically in Figure 15 opposite.

The extent to which a nation approaches self-sufficiency in minerals depends even more upon a well balanced supply than upon large reserves of a few materials. It is reassuring, therefore, to learn that the United States contributes a noteworthy amount to the world's production of all but seven of the 30 leading mineral commodities. This deficiency is very much lower than that of any other country, but even in some of these seven commodities the deficiency should not be considered serious. During the last few years plants have been erected in the United States for the synthetic production of nitrates; increased prices have immensely stimulated the domestic production of manganese and chromite; and potash is now produced in quantities sufficient to meet the more pressing domestic requirements, although not yet at a cost low enough to compete with that from the great bedded deposits of Stassfurt and Alsace. Domestic deposits of ores of nickel have been known for many years, but have not been worked because of the great supply of higher-grade ore in Canada. In tin and platinum, and in these alone, does it seem necessary at present to recognize a deficiency in our supply of absolutely essential metals that must be made up almost wholly by imports. For a part of our supply of several commodities, however, such as manganese, chromite, and antimony, we may still have to draw on foreign deposits.

Far more noteworthy than these few deficiencies is the fact that in the output of coal, iron, copper, lead, zinc, and petroleum, the mineral commodities that enter more extensively into modern industry than any others, the United States holds first place. To these might be

added aluminum, for although France produced more aluminum in 1913 than the United States our reserves are about as large as hers.

The contribution made by the United States to the world's mineral output shows clearly the fundamental soundness of her present position among industrial nations. If another holds the place of a close second or even stands first, it is not because of natural endowment of mineral wealth, but because of more complete utilization of home supplies combined with a large import trade in raw materials. A German has truly said of his country: "We must export to be able to import, and we must import to be able to work and live." In so far as we supply the manufacturers of a foreign country with their raw material, we are not only exhausting our mineral supplies, which should be our most cherished raw materials, but we are failing to use them to the fullest extent in the profitable employment of our labor in this and later generations. To withhold our minerals from the markets of the world would be undemocratic and might create international friction, but to plan that more and more of them shall enter those markets in fully manufactured form would be to promote a growth and prosperity which should be in no way unjust to other nations. "The increase of the element of labor in the product exported will mean that we are not bartering away our heritage of natural resources but rather that we are using these resources as a basis simply for the expenditure of labor, which renews itself."[2]

Although our present-day possibilities are clearly shown by our current contribution to the world's min-

[2] George Otis Smith, "Distribution of Industrial Opportunities," *Transactions of the American Institute of Chemical Engineers*, vii, 1914.

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situation will be most adequate if we consider first the distribution of coal, the reserves of which are doubtless more truly shown by recent estimates than those of iron. In certain geologic periods the climatic and other conditions were favorable to the growth of coal-forming plants and to the accumulation of great layers of plant remains; in others, the growth of vegetation was comparatively meagre. The accumulation of extensive beds of coal, however, required not only an abundance of rank vegetation, but the existence of lowlands in which the conditions were favorable for its preservation. The places where the climate and topography together produced the conditions necessary to great beds of coal can readily be found by the geologist, and, moreover, the typical coal-bearing formations extend over great areas and are so rich in fossils that they are not likely to have been overlooked or incorrectly identified. Finally, in countries not richly endowed with coal search has been made for it as zealously as for any other mineral. For these reasons we may accept as satisfactory for our purpose the estimates brought together from all countries by the International Geologic Congress of 1913.

These estimates show that over 96 per cent. of the world's coal is in the Northern Hemisphere. The Southern Hemisphere, with the possible exception of Antarctica, is comparatively destitute of coal. About 70 per cent. of the world's supply is found in North America, and over 50 per cent. of it in the United States. Among the countries of Europe, Germany was more richly endowed than any other, having more than half the European reserves, yet the German supply was only about one-eighth that of the United States. The United States contains more than 21 times as much coal as Great Britain, whose coal mines have been the funda-

mental source of her great maritime activity, both by contributing the largest export commodity and by furnishing bunker coal to the steamships of all nations. The advantage that America holds over England through a larger supply of coal is enhanced by the difference in the cost of coal at the mines, for the cost (1913) in England is nearly twice as great as in this country. This difference is due in part to a smaller use of machinery in British mines and in part to the greater depth of the available British coal. The export trade in British coal, however, is greatly aided by the proximity of her mines to tidewater.

The larger coal fields of the world, except those of China, are within the north Atlantic drainage basin. China, however, has reserves exceeding those of Europe, and with cheap labor and this abundant source of energy she is likely to play a prominent part in the world's industries. But China's resources in iron, the indispensable adjunct of coal in many fundamental industries, now seem to be much smaller than has been commonly stated.

The principal known iron-ore reserves, like the coal reserves, are grouped strikingly around the north Atlantic basin. In the Southern Hemisphere we find one large group of deposits in southeastern Brazil and smaller deposits in Chile, Australia, and South Africa. Of these only the deposits in Australia are near coal, and the reserves there are so small in comparison with those of North America and western Europe as to be scarcely worthy of consideration in any attempt to determine the sources of the world's future supply of iron.

The world's iron resources, however, are much less completely known than its coal resources. Although on every continent and in every country the total amount

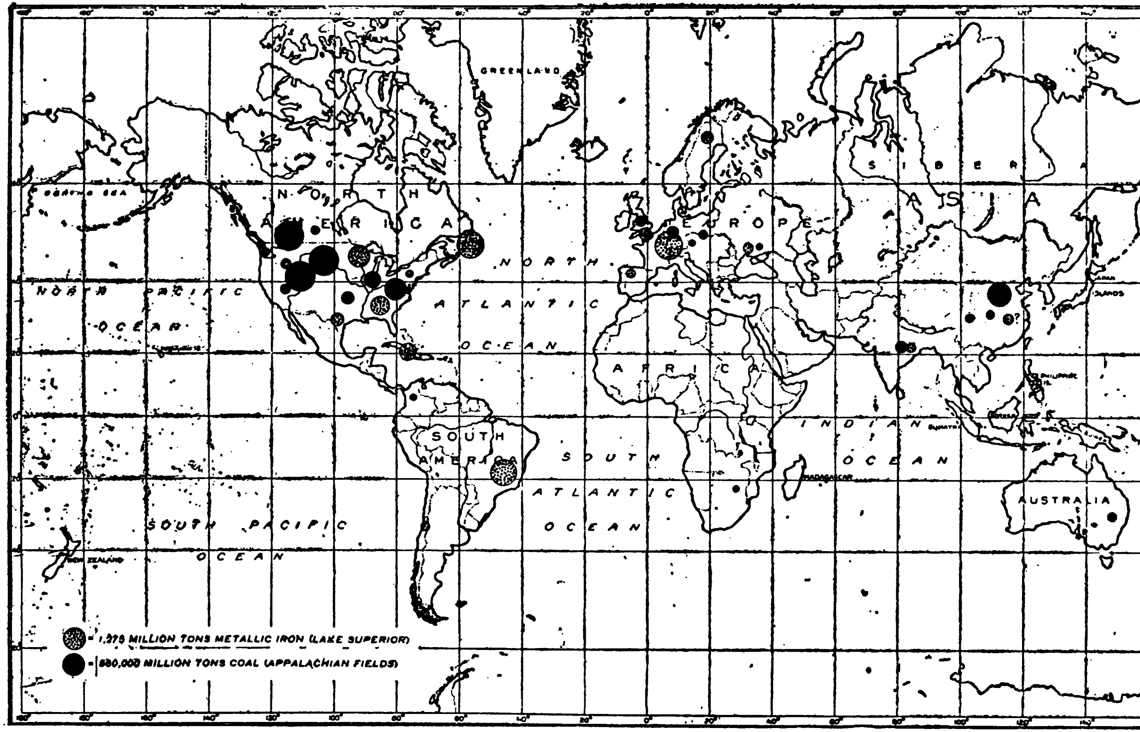

FIGURE 16. DISTRIBUTION AND RELATIVE SIZE OF THE CHIEF IRON AND COAL RESERVES OF THE WORLD. AREAS OF SYMBOLS ARE PROPORTIONAL TO THE EXTENT OF KNOWN RESERVES, BASED ON GRADES OF ORE NOW MARKETABLE

of iron vastly exceeds that of coal, yet the commercial deposits of iron ore are much less numerous than those of coal, and until they are fully developed, estimates of their content are much more uncertain. Iron makes up nearly 4½ per cent. of the earth's crust, yet to be of commercial grade an ore must contain a much larger percentage of iron than this, and in the process of natural concentration objectionable impurities must have been largely eliminated. An accurate estimate of the world's iron reserves is also made difficult by the great variation in the iron content of the ore. For every ton of ore that contains 60 per cent. of iron, there are many tons that contain 50 per cent., and for every ton that contains 45 per cent., there are a very great number of tons that contain only 35 per cent. Thus, the amount of iron ore credited to any district is largely influenced by the grade of material included in the estimate. This fact is well shown by the range from 2,000 million to 72,000 million tons credited to the Lake Superior deposits, the lower figure representing the grade of ore now mined, and the higher figure the probable or possible grade of ore later to be utilized. Furthermore, a refractory ore containing 50 per cent. of iron is no more desirable than a self-fluxing ore containing 35 per cent. This difference in iron content also makes any comparison by tonnage of ore almost meaningless, for the value of an ore deposit as a national asset lies in the amount of metal it can supply at reasonable cost.

In comparing the iron reserves of different countries it seems necessary, therefore, to consider only ores that are commercially available under conditions such as prevailed just before the war, and to compare them by their content of iron. Such a comparison, shown graphically

in Figure 16, gives a fair idea of the preëminence of the North American continent in iron reserves as compared with the rest of the world.[3] In the Southern Hemisphere, South America has much iron in Brazil, but almost no coal; Africa is exceptionally deficient in both coal and iron; Australia has both, but in quantities insufficient for any very great industrial growth. The coal and iron of India are destined to support a large industrial center in the general vicinity of Calcutta, but when India's reserves are compared with those of other countries, it becomes quite clear that even if she should ever attain a high place among the industrial nations, she could not hold it long. In respect to these two minerals China is at present the great unknown quantity. Geologists and engineers returning from that country confirm the statements that her coal resources are tremendous, but they seem to agree that the early estimates of her iron reserves were grossly excessive. Iron occurs at many places in China, but most of the individual deposits are small compared with those of the iron ranges of our own Lake Superior region and the districts of western Europe.

From the viewpoint of the world economist, therefore, a census of iron-ore reserves need include only the United States, Cuba, Newfoundland, Brazil, and the countries of Europe. The field of competition may be limited even further, as the only European countries that contain large iron reserves are France, Great Britain, Sweden, and Russia. Sweden, like Brazil, has high-grade iron but no coal. Great Britain has coal and iron ore, but the cream has been skimmed from both,

[3] The values used are those given in *Iron Ores,* by E. C. Eckel, and in the report of the International Geologic Congress, with minor changes for Brazil and China based on more recent information.

so that she is now raising deeply buried coal and working low-grade iron ore. A considerable iron industry may eventually be developed in the area north of the Black Sea, but the reserves of both coal and iron in that area are comparable with those of India rather than with those of the United States and Central Europe. The greatest iron-ore field of Europe significantly occupies an area that has been partly in France, partly in Germany, and partly in Luxemburg. Of these three countries France held the larger reserves, but the depth of the iron-bearing formation increases toward the west, so that the ore in German Lorraine could be mined more cheaply than that in France. What is still more important, France has no adequate supply of high grade coking coal, even with the acquisition of the Saar Basin, whereas Germany has large supplies of the finest coking coal in Europe. Among European countries, then, Germany has been by far the best endowed by nature for a great iron and steel industry and the innumerable other industries that are related to it. Even since the Lorraine iron deposits have gone to France, Germany still occupies a strong industrial position because there are important economies in moving iron to coal fields rather than moving coal to iron fields; it requires one and one-half tons of coal to make one ton of pig iron and from three to five tons to make one ton of fabricated steel.

In North America there are great deposits of iron ore in Newfoundland, Cuba, and the United States. The deposits of Newfoundland represent probably the largest single reserve of high-grade iron ore in the world, but most of the ore lies beneath the waters of Conception Bay, so that only 4,000 million tons out of 10,000 million tons is considered recoverable. Newfoundland has comparatively little coal, however, and except small de-

posits in Nova Scotia, the coal of Canada lies far inland. Cuba also has large reserves of iron ore — about 3,000 million tons — but no coal. The United States, on the other hand, according to the estimates, has more minable iron ore of present commercial grade than Cuba and Newfoundland combined, and in addition has half the world's coal.

It is enlightening to compare the iron reserves of the United States, the largest in North America, with those of France, the largest in Europe. Here again we find our own reserves proponderant, for they are nearly twice as great as those of France. Because of the abundant coal and the peculiar properties of the Lorraine iron ore, Germany and France will probably continue to feed their furnaces partly from the reserves of Sweden, and later, possibly, from those of Russia; but, again, the deposits of Newfoundland and Cuba, tributary to the coal supply of the United States, are several times larger than those tributary to the Westphalia coal field.

Minerals other than coal and iron are widely used in modern industries, and these also are notably concentrated within our own country. Conspicuous among them is copper, because of its large use in the rapidly expanding electrical industry.

The United States produces over half the world's copper. It is followed in order of production by Japan, Chile, Canada, Mexico, Spain and Portugal, Peru, Australia, Germany, and Norway, but the order of production may not closely represent the order of size of the reserves. In copper the United States will doubtless continue to hold first place for many years; indeed, it may contain the world's greatest copper reserves. Chile will soon attain second rank, and Russia and the Belgian Kongo are sure to come toward the front. Japan

can be self-supporting in copper for a long time, but her supply is probably not large enough to warrant heavy exports, and Australia seems to be similarly situated. Western Europe as a whole is not likely to augment greatly its present annual production and will therefore afford an increasingly eager market for copper. Asia will no doubt increase its output, but may not be able to keep pace with her own growing demand.

The world's reserves of copper cannot be closely estimated, and comparisons for copper such as those just made for coal and iron are therefore impossible. The United States, however, has greater copper reserves now actually developed than any other country — even more than Europe, Asia, and Africa combined, and the Cordillera of the two Americas is probably the storehouse of the world's future supply. In this general belt the reserves appear to be especially large within the segments embraced by the United States and Chile, with the greater quantity in the United States. However, so many large reserves have been discovered in this general region during the last few years, and the rich copper districts cover areas so small — the largest covering only a few square miles — that any forecast as to the location or distribution of deposits that may yet be discovered would be hazardous. On the other hand, few minerals have been more widely and more earnestly sought in recent years than copper, so that it may be safe to say that the world's principal reserves of copper ore of present commercial grade are already known. The demand for copper is so great and is increasing so rapidly that we cannot forsee how it will be met 50 or 75 years hence, even if we assume that the world's reserves are only half known and that progress in metallurgy will double the amount recoverable. Thus

it appears inevitable that in the comparatively near future, aluminum, the best substitute for copper as an electrical conductor, will become increasingly valuable as a national asset.

The world's great reserves of aluminum are contained in the bauxite deposits of France and the United States and in the soils of the tropics of South America, Africa, and India. These reserves are sufficient for many generations, and long before they are gone means doubtless will be found for winning aluminum from the aluminum-rich rocks, of which the world has an inexhaustible supply.

Valuable deposits of lead and zinc occur in many countries, and although the United States almost certainly has larger reserves than any other, our position with respect to these metals is not so strikingly preeminent as it is with respect to certain other minerals. Indeed, it is likely that the increased supply of lead and zinc demanded by the world's industrial expansion will come from other countries, although we shall doubtless maintain our present annual output for a long time. One of the largest known deposits of lead and zinc has recently been opened in Burma, and one of the greatest zinc fields in the world is in Silesia. For many centuries Spain has been an important source of much lead, and for a number of years has been exceeded in annual output only by the United States. Several large deposits of lead and zinc have been opened in recent years in Siberia, and others are known. The Broken Hill district, in New South Wales, and the island of Sardinia, in the Mediterranean, are notable sources of both metals, and although the reserves are not so large as those in some other countries, they constitute highly valuable world assets. Algeria, Sweden, and Austria

have large zinc resources, and Mexico contains considerable deposits of both lead and zinc.

Copper, aluminum, lead, and zinc form an industrially related group of metals in which the United States is far more richly endowed than any other country. Chile, perhaps her rival in copper, is meagrely supplied with the other three metals. Germany, with great reserves of zinc and considerable lead, has no aluminum and comparatively little copper. France has aluminum but is conspicuously deficient in the other three. Spain has all except aluminum in good amounts, and India has all except copper.

Certain less common metals — manganese, chromite, nickel, vanadium, tungsten and molybdenum — are added to iron to make the varieties of steel demanded by modern industry. Comparatively small amounts of these metals are used, and hence they are moved, often long distances, to the industrial centers determined by the location of deposits of iron and coal. It is of interest to note that the United States is more richly supplied with more of these metals than any other nation, and that in only two of them is she seriously deficient. The world's principal manganese reserves are in Russia, India, and Brazil, and large deposits of chromite are known only in Asiatic Turkey, Rhodesia, New Caledonia, and the Ural Mountains of Russia. On the other hand, none of these countries appears to have large deposits of nickel (except New Caledonia), or of vanadium, tungsten, or molybdenum. High-grade manganese and chromite ores occur at many places in the United States, but the deposits appear to be small, and when ocean freight rates are normal, probably cannot compete, even in the domestic market, with foreign supplies.

The United States contains the world's greatest re-

sources of natural gas and petroleum. The leading known petroleum reserves of the world are in the United States, Mexico, southern Russia, Rumania, and the northern countries of South America. The large and greatly increasing use of petroleum and its products is rapidly depleting these reserves, and in looking into the future, therefore, we should inquire into the distribution of those shale formations which are so thoroughly impregnated with vegetal remains that petroleum may be collected from them on a commercial scale by distillation. The oil shales of Colorado and Utah represent an untouched reserve of petroleum which is three or four times greater than that in our oil pools before the first well was drilled in Pennsylvania, and within a year petroleum will probably be distilled from these shales in competition with that obtained from wells. Large deposits of similar shales are found in the British Isles, where they are mined for their oil, in western Russia, and probably in Australia.

The fertilizer industry is based predominantly on potash, nitrates, and phosphates. Pyrite and sulphur, from which sulphuric acid is made, are closely related to this group, because rock phosphate must be treated with acid to make it available for plant consumption. All these minerals except pyrite are found in only a few countries. Most of the potash in the world occurs in one area in Germany, one in Alsace, and possibly one in northeastern Spain and one in Abyssinia. Chile has nearly all the nitrates. It is possible for us, however, in the future to make up for our lack of deposits of nitrates and potash and supply all our domestic needs by collecting nitrogen from the air and by making potash as a by-product of blast furnaces and cement works. The principal reserves of phosphate rock are in the United

States, in the Moscow basin of Russia, and in Algeria and Tunis. Sulphur is largely concentrated in Sicily and our own Gulf States. Pyrite, on the other hand, occurs in most countries, although it is found at few places in favorably situated deposits large or pure enough to compete with those of Huelva, Spain.

Of two of the precious metals, gold and silver, our supply is large compared with that of most other countries. In gold our reserves are probably second only to those of the other "U. S. A." — the Union of South Africa, and in silver we are possibly as well off as any other nation. There are, however, only two large sources of the third precious metal, platinum — the Ural Mountains in Russia and a few valleys in Colombia.

Only a few other useful minerals, such as graphite, magnesite, tin, mercury, antimony, and arsenic, remain to be considered. Of magnesite and arsenic we have abundance, and the United States is one of the four principal mercury-producing countries, the others being Spain, Italy, and Austria. We have some antimony and a negligible amount of tin, the world's chief supply of both tin and antimony being in southern Asia and in Bolivia. For graphite of the highest quality we, with other industrial nations, may find it expedient to import largely from Madagascar and Ceylon and possibly from Greenland, even though our own resources are large.

The foregoing review of the world's mineral reserves indicates clearly that the United States is the world's greatest storehouse of the useful minerals. This mineral wealth is an endowment for which we should be grateful, but its possession entails a responsibility to other peoples which should be fully recognized and incorporated in our national policy. Our attitude to these

supplies should be that of stewardship rather than of absolute ownership; by accident only are we thus more favored than others. To withhold our mineral supplies from the rest of the world would be to lay the foundation for future wars, but to send these necessities of civilization to other countries in forms as nearly ready for use as possible will support the largest and most diversified industry at home and make most strongly for national growth and prosperity. There is not only an interdependence among nations with respect to mineral supplies that is due to the erratic distribution and localization of the deposits, but an international obligation rests upon the possessors of the supplies, for all peoples may justly claim an equity in the world's mineral resources — an inherent right to the greater comforts and efficiency of life that are incident to their use. In brief, the position of the United States among the nations is that of the world's greatest storehouse of mineral wealth. Our interest in this wealth is that of steward and part owner.

With this endowment of mineral wealth, far greater than that of any other nation, in the hands of a people of exceptional ingenuity and vigor, living in a country of which it has been said that the world hardly contains another area so large and so well adapted to civilized occupation, and with the development of this wealth already far advanced, the United States is destined to be for many generations the great center of world industry, a veritable seat of peaceful world empire.

CHAPTER XII

A CASE OF NATIONAL DEPENDENCE: GERMANY

FRANK F. GROUT[1]

Position in mineral wealth — Economic weakness in raw materials — Dependence on overseas trade — Several kinds of preparedness — Eleventh hour imports of metals and minerals — Plans for war.

In marked contrast to the United States in her position of mineral independence among the nations stands Germany. Germany has only one mineral, potash, the production of which dominates world trade. She has an exportable or potential surplus of coal and cement and possibly of zinc. Of other mineral commodities, comprising a long list, Germany must import considerable amounts to fill her requirements.

Each of the prominent industrial nations has a supply of coal and iron. Germany has ranked second only to the United States in the production of these essentials of industry. On the basis of these two minerals her power has been developed. Even in these, however, her situation was not wholly satisfactory, and in other accessory minerals, especially the steel alloy metals, she was not at all well endowed.

Germany's supplies of iron came largely from Lorraine and Luxemburg, over which her control was not as complete as she wished. The earliest moves in the Great War showed her desire to make that control more firm and extensive. Since Lorraine iron is to be under French control hereafter, Germany's output of iron ore

[1] United States Shipping Board.

will be surpassed by the production of half a dozen other powers.

Along with the Lorraine iron ores Germany loses her main supplies of phosphate fertilizer, obtained as a by-product of the manufacture of steel. In this her requirements are large and are only about half fulfilled by the use of phosphatic slags. Germany has no other important phosphate supply; and the shortage of this material largely counterbalances her dominant supply of potash. It thus appears that in the minerals most vital to industrial power and intensive agriculture the German position, far from satisfactory before the war, is now relatively very weak.

With respect to certain of the minor metals and minerals the Central Empires were approximately independent, but for a longer list they required large imports, and on any interruption of imports they were faced with a grave shortage. The minerals which Germany might produce in nearly the required amounts included lead, zinc, bauxite (aluminum ore), silver, antimony, graphite, and pyrite. Large imports were needed of other minerals. In the list of countries producing these minerals Germany ranked very low in the years immediately preceding the war. In sulphur and nickel production Germany ranked eighth; in copper, tenth; in tin, thirteenth; in petroleum, fourteenth; in tungsten, seventeenth; in manganese and gold, eighteenth; while in platinum, chromite, mercury, mica, and monazite no German production is recorded — and all of these minerals are essential in time of peace or of war. Some of Germany's necessary mineral imports could be derived from Russia and Austria, but certain items were required from overseas. Iron was brought from Sweden, nickel from the United States, molybdenum from Norway, phos-

phates from the United States and the French colonies, copper from the United States, tin from England and the Straits Settlements, petroleum from the United States, mica from India, monazite from India and Brazil, manganese from India, etc.

It is evident that a successful war, aside from preparation in German diplomatic and financial circles, required preparation for continued mineral supplies. Different kinds of action were possible, the particular kind depending on the domestic supplies and the tonnage of material involved. For example, there are deposits of copper in central Europe which can be made productive if given the necessary stimulus regardless of expense; but Germany needed so much copper that, in spite of increased imports from United States, it was quite impossible for her to lay in a stock that would obviate the necessity of forced production. The case of nickel was almost the opposite, for no amount of effort would result in sufficient production in Europe to fill demands. Stocks are necessary if continued imports are not assured. In certain other minerals, however, such as graphite and tin, substitutes may be encouraged to the point of relieving much of the shortage.

Perhaps the most difficult metal to provide was manganese. The tonnage involved is too large to be easily stocked, but the stock piles are known to have existed in Germany, and these probably served to meet all demands for two years of war. It must have taken over a year, however, to accumulate such stocks. Imports of manganese alloys from England were also large for three years beginning in 1912. For the other steel alloy materials, such as chrome ore and tungsten ore, Germany depended on Austria.

Study of the several mineral commodities shows that

in respect to each one Germany had made full preparations, depending on the nature of the mineral, with the plain purpose of being independent of overseas imports for a time ranging from two to five years. Even in her export trade she may have made a similar effort to be prepared. There is a record of certain orders for delivery in the fall of 1914 that were filled by German exporters in the spring of 1914.

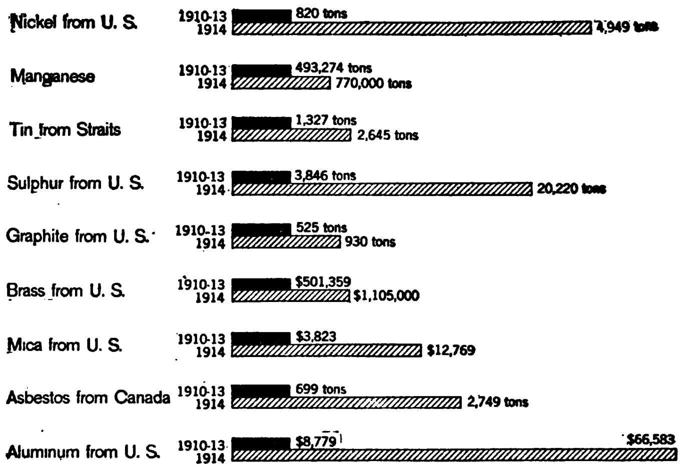

FIGURE 17. GERMAN MINERAL IMPORTS, IN 1914 AS COMPARED WITH THE PRECEDING FOUR-YEAR AVERAGE

The tables of mineral imports show a sudden increase in German imports in the year just preceding the Great War. Figure 17 shows graphically the difference in the imports of that year and the preceding years. This sudden increase was not due to the normal growth of German trade, neither can it be explained as due to changes in metallurgy or mineral discoveries. It was evidently a measure of preparedness. To emphasize this

eleventh-hour activity in mineral importation, these figures of German imports of all commodities are given:

Fiscal Year	Total, metric tons	From United States, value
1910..........	64,496,059	$249,555,926
1911..........	68,399,429	287,495,814
1912..........	71,102,531	306,959,021
1913..........	72,830,781	331,684,212
1914..........	No data	344,794,276

The average annual increase in total imports is less than seven per cent. and shows no sudden rise just before the war. In contrast with the general trade, however, the imports of some metals and minerals rose several hundred per cent. Certain items are noteworthy.

Manganese is one of the chief steel alloys, and large amounts are needed in making munitions. The average consumption of manganese ore per ton of steel produced in Germany from 1909 to 1912, inclusive, was 56 pounds. In the first six months of 1914 the imports would indicate a consumption of 96 pounds per ton of steel produced. There was no significant change in steel practice at that time, and the year's production of steel in Germany was smaller than in 1913. The excess was undoubtedly put into stock. *Mineral Industry* for 1915 reports that in the year preceding the war Germany imported twice the ordinary amount of manganese ore from Russia and India. A Belgian engineer reported that at the beginning of the war most German steel works had a reserve of manganese supplies to last several months.[2]

Nickel reached Germany chiefly from Canada through the refineries in United States. The increase in shipments in the year preceding July 1, 1914, is the most striking example of preparation for interruption of im-

[2] *Iron Age*, April 27, 1916.

Calendar year	Manganese Ore,[1] metric tons	Tin from Straits,[2] tons	Asbestos from Canada,[3] tons
1910.....	384,145	Less than 1,073[5]	440
1911.....	487,872	Less than 1,777[5]	351
1912.....	420,709	Less than 1,770[5]	1,155
1913.....	680,371	1,327	840
1914...	Estimated, 770,000 First half, 385,686	2,645	2,749

Fiscal year	Nickel from United States,[4] pounds	Mica from United States,[4] value	Sulphur from United States,[4] tons
1910.......	548,589	$1,815	1,999
1911.......	1,902,393	3,404	1,355
1912.......	2,527,273	3,250	3,790
1913.......	2,346,325	6,823	8,241
1914.......	11,084,366	12,769	20,226

Fiscal year	Aluminum and manufactures from United States,[4] value	Graphite from United States,[4] pounds	Brass, all crude forms, from United States,[4] value
1910.......	$2,576	1,127,178	$197,693
1911.......	3,294	1,252,802	506,743
1912.......	3,764	1,265,456	708,000
1913.......	25,483	1,057,799	593,000
1914.......	66,583	2,082,464	1,105,000

[1] *Mineral Industry; Glück auf,* Vol. 50, Part. 11. [2] U. S. Consular Reports. [3] Department of Mines of Canada, Mines Branch, Annual Report, 1918. [4] "Commerce and Navigation of the United States." [5] Shipments to all Continental Europe.

ports. It is highly improbable that Germany in 1914 used over four times as much nickel as ever before.

Tin import statistics are not complete, but the sudden increase in shipments from the Straits may indicate that there was an effort to get in a supply. Shipments from England and Sweden also showed a rapid increase. Those from England *via* Sweden continued in 1915.

Sulphur is of importance in both peace and war industries, and the United States is one of the principal sources. Although pyrite is a substitute that is available to Germany, the increased quantity of sulphur imported probably went largely into stocks, for purposes in which pyrite is less desirable.

Graphite occurs in the Central Empires in several grades. The changes in Austrian production are significant of a certain amount of preparedness. American graphite is of other quality, and that imported by Germany from the United States was evidently used for purposes for which her own graphite was less suitable.

It is clear that before the first of July, 1914, Germany had prepared her mineral industry for a period of independence of overseas trade. This at once suggests that before the middle of 1914 plans had been made for action that might interfere with normal trade. Furthermore, the preparations were especially notable in those metals and minerals which are needed for military operations — steel alloys, electric insulation, etc. Along with many diplomatic documents this furnishes cumulative evidence of the deliberate plans for war by the militaristic group in Germany. How far the failure of these plans was due to the exhaustion of mineral stocks is not yet fully known, but the shortage of some metals certainly played an important part.

CHAPTER XIII

A LOOK AHEAD

GEORGE OTIS SMITH[1]

Preparedness for peace — Minerals as working capital — Significance of power resources — Thrift in distribution — Organization of industry — "The land of unlimited possibilities" — Efficiency for economic defense — American industry and world commerce — Industrial democracy — The Golden Rule in economics.

A nation may be as short-sighted in disposing of its natural resources as the Russian committee of workmen who, on assuming the control and attempting the management of a factory, sold whatever raw materials they found stored on the premises in order to pay their own wages and those of their fellows. Plainly bolshevism takes no thought of the morrow.

The period on which the world is entering at the close of the most destructive war mankind has ever suffered perhaps may deserve to be called the Industrial Renaissance. The recent experience of every nation has forced home a clearer realization of the dependence of industry upon raw materials, and in this respect America's strategic position has been tested as never before. The possession of natural wealth laid upon us as a nation the burden of feeding our neighbors in Europe — the neutrals as well as our allies, of supplying the Allied armies with the material for the munitions of war, and of restoring the merchant marine necessary to bridge the Atlantic. This war-time test was met by a nation handicapped by an unfortunate lack of preparedness for war.

[1] United States Geological Survey.

Preparedness for peace should appeal to us now and more forcibly because of the lessons we learned in the hard school of war.

The industrial factor in the many-sided problems of reconstruction is well suggested by some of the titles in a series of leaflets issued by a well-known New York financial institution: "Taking Stock of the Future," "A Record that is a Promise," "The Inspiration of Adversity," "Organizing for the Victories of Peace," "Adjusting Industry to a New Peace Basis." The inventories of American mineral assets in the preceding chapters of this volume, the promise of what America can do as forecast in the rapid industrial growth of the last three or four years, and the lessons in thrift we have been forced to learn because of the temporary barriers to international commerce, all these should prompt us to prepare for peace, to organize our industry and to adjust it so as to make best use of the new era, not only to benefit ourselves but to help our neighbors the world over.

Thoughtful Americans may well ask these questions: Whither have we been drifting in the rapidly changing currents of business procedure and industrial control? Is there a well defined purpose in all this adjustment and readjustment of the practice to which we had become accustomed? Plainly, if all these changes or advances are directed toward a definite goal, we shall do well to know it, to observe our trend, and to gauge our progress toward that goal. First of all, however, we need to see that goal — to convince ourselves what it is all about. Hence the present need of the look ahead.

Industry is not an end unto itself. Before production comes demand, and production and consumption must each measure up to both national needs and individual

welfare. Again and again we must take the forward look. Big business with its huge investment must commonly take the longer look ahead than the man of a small undertaking in the same line. America's wealth in natural resources should lead her likewise to exercise more foresight than a smaller country whose future needs and possibilities are less.

The value to a nation of its minerals is shown by the proposals of war indemnities in terms of mineral lands, which statesmen now correctly regard both as national assets and as industrial capital. Indeed, this idea is not at all novel, for it is no longer debatable that in the settlement of 1871 the unmined iron of Lorraine has outweighed in value to Germany the millions of coined gold also exacted of France. Just as a steel company in its effort to operate efficiently its own business mines its own coal and ore, so it is highly advantageous for an industrial nation to control its own supplies of raw materials.

Yet, as has been stated already in this volume, the strategic value of a nation's minerals is not best gained by holding them as reserves, as a line of national defense. The principle that title to territory justly rests upon its best use should win the recognition in international equity that it is now winning in questions between the private owner and the public. The condemnation of idle private land for public use is surely coming, whether the needs of society are expressed in war-time need of ore in America or of grain in England. A nation's resources are of largest value if they serve the world. "We are to grow nationally by our generosity internationally."

In the valuation of mineral resources the power factor

takes on large significance. American workmen are more productive, man for man, than the labor of any other country, but this gratifying superiority expresses not so much a difference in men as in machines. Whether in the factory or on the farm, the American is the world's greatest user of machinery.

Industrial expansion is dependent upon cheap power, and this dependence is best demonstrated whenever industry becomes competitive, either between two towns in the same state or between two countries on different continents; then the possession of cheaper power may become the decisive factor. Cheap power more than offsets cheap labor, for machinery multiplies man power and gives to skilled labor an earning capacity that makes possible a community of large consumers.

The world's current income, according to an English economist, is the heat and light received annually from the sun — but, we may add, payable daily. Following this thought further, he refers to coal as representing the earth's accumulated savings from the same source, a store of capital that should not be squandered; yet again we may add that coal, like other capital, is to be used and not hoarded. Cheap coal, indeed, is the greatest asset of any country. The possession of large supplies of coal and fuel oil for both naval and merchant marine is not only one of the material guarantees that can be used to enforce peace, but these mineral fuels are of greatest value as the source of power. The largest consumer of coal, the United States, to a large extent is burning its coal for other nations; the machines that manufacture for world consumption are turned by the coal burned at American power plants, and this immense use of coal is the gratifying test of industrial capacity.

Yet, both these mineral fuels with which our country is so abundantly blessed are expendible resources, (already 40 per cent. of our oil is believed to have been brought to the surface) whereas our swiftly flowing streams furnish a non-expendible source of power. In the West hydro-electric power has already passed coal and oil in the competition in which low cost wins, but in the East the latest steam plants, with their largely increased efficiency, afford the promise of continued cheap power even with advancing cost of coal.

Too much foresight cannot be devoted to America's power requirements. The war-time expansion of industry brought us face to face with a shortage of power, and we have taken the consequent training in thrift. Power plants are being interconnected, power needs pooled, and power installations used more efficiently and economically. The best steam plants of the country consume less than two pounds of coal per kilowatt-hour, yet since small plants require from three to five pounds, and plants operated only during the night may use even 15 or more pounds to generate the same unit, it is plain that national economy in coal consumption can be attained only by large up-to-date plants so interconnected as to render the best service to the public. Already Congress has been asked to authorize an investigation looking to a comprehensive plan of one power supply for the Boston-Washington industrial region, with a trunk transmission line connecting up water-power plants and steam-power plants, from which a score of railroads, hundreds of public-service companies, and thousands of manufacturing plants would draw the energy for their operations. This would mean fuel saving on a national scale and in figures worthy of American engineering.

America, with her large stock of raw material and her genius for industrial efficiency, would fall far short of full utilization of national opportunity without some large supply of energy to turn the wheels of industry. The two- or three-fold larger output of the American workman as compared with that of his British cousin is explained by the correspondingly larger number of horse power used per thousand operatives. In Great Britain and Ireland the industrial power requirement in 1907 was about 10,500,000 horse power, of which only 1.6 per cent., or 180,000 horse power, was water power. With this is to be contrasted a present installation of water power in the United States of between eight and nine millions. Moreover, we have perhaps seven times that amount of available undeveloped water power, without storage. Compare with such large possibilities the estimate of 375,000 horse power available in Scotland, and that only with storage, and the advantage in power assets of this country becomes apparent. This comparison gives point to the Board of Trade report of 1917 which urges for the United Kingdom a "scientific replanning" of electric-power distribution from large central stations which would effect an annual saving of not less than 50 million tons of coal and "more than compensate for the absence of large water powers" in the industrial region of England and Wales. The supply of electrical energy is regarded as a "key industry" and as long as the power system of Great Britain is "behind the times," it is "a serious handicap in international competition."

If there is to be any rivalry among nations in organizing industry so as to put all material resources to their highest use, America's stategic position will rest upon her unsurpassed reserves of coal reinforced by her large

and well distributed water-power resources. Macfarlane, in his *Economic Basis of an Enduring Peace,* develops the thesis that the balance of political power in Europe must be secured through a more equal division of coal lands. Our own possession of nearly 55 per cent. of the world's known coal suggests where the balance of industrial strength lies. Nevertheless, the United States needs to make the best use of these sources of motive power if labor is to be conserved to the greatest extent possible.

Cheap and adequate transportation, like cheap and abundant power, is a potent friend of industry. The emphasis which all wars have placed upon trade routes suggests the large part that transportation lines play in the strategy of minerals as utilized by mankind. Economic distribution of raw material and of manufactured product is half the battle in winning low-cost production. If adequate means of distribution of product are lacking, resources, however great, cannot benefit either the nation or the world. The millions of bushels of wheat spoiling at Australian ports while the people of England had to look for food to Canada and the United States furnished a sad illustration of this truth, and through the shortage in shipping due to submarine warfare the world learned the real significance in cost and risk of the long haul in ocean-borne commerce.

Thrift in distribution concerns both overseas and interstate traffic; the home market always has the transportation cost in its favor, and for similar reasons we can better exchange products with Cuba and Brazil than with India or South Africa. Distance is a hard fact to contend with, and therefore every possible economy that can be introduced into our transportation

system adds to our industrial welfare. The waste inherent in the enforced railroad competition of the past may now be avoided, and rates based solely upon distance traveled and service rendered will promote the economical distribution of raw material. Equalizing industrial opportunities by arbitrary rate making is wasteful because it runs counter to nature, and the public sooner or later pays whatever was not included in the artificial rates. The freight differential that favors this industry or that community suggests too strongly the German idea that a state railway system is simply an instrument to promote certain industries at whatever cost to other users of transportation. Equality of treatment is sacrificed to success in foreign markets. In Germany the State-fixed rate has favored the big industries in much the same way as preferred corporations were once favored by our secret rebates.

The close connection between thrift in transportation and the best use of minerals in industrial strategy is indicated by the figures showing, by classes of commodities, the freight tonnage of our railroad traffic. The mines and smelters, oil wells and refineries, quarries and cement kilns furnish more than four million tons of freight a day, or nearly two-thirds of the total traffic on the railroads of the country. Two items, anthracite and petroleum, alone nearly equal the total foodstuffs. Even in a single commodity, artificial fertilizer, wartime thrift in car loading accomplished an average increase of 40 per cent. in the load to the car, or a saving in car service of 75,000 to 87,000 freight cars. The world's work requires efficiency and economy of this type even now after the period of emergency has passed.

With bituminous coal the largest single item of railroad freight, economy in its transportation becomes a

matter of large and national moment. The railroad president who sees in long-distance transmission of electricity from mine-mouth to consumer the opportunity to relieve his congested lines of their burden of coal has a vision broad enough to take in the future development of his territory that will fully replace this freight with more profitable traffic. Electrification of our railroads is the next step in the programme of transportation thrift.

There is a broader outlook than can express itself in terms of either organized labor or organized capital. The organization of industry now needed is organization for enduring peace, the sum total of economic adjustment that must come if peace is to abide and yield its best fruits to humanity.

The search for a basis of permanent peace thus becomes a campaign for economic defense. The strong national reaction against the waste of war finds voice in the universal appeal that the recent sacrifice shall not have been in vain; the price having been paid, *any* peace is not sufficient. As a writer in the *Annalist* has recently put it, America's greatest fault, with all her native ability and vast resources, is in not planning for the future. "A Franklin among us would not permit Germany to be the only nation to plan long years ahead, but his planning would be for the democratization of the world, not for its subjugation."

In 1918 a German naval officer, in referring to our industrial mobilization, called America the "land of unlimited possibilities." Our country is probably of all countries most nearly self-sufficient in capital and labor as well as in raw material, yet there is none the less need of efficiency in the use of material, men, and money.

Indeed, the non-waste of man power is more important than the conservation of raw material, and organization of industry means first of all the best use of labor — the use that is most productive of things the nation needs. Thus, the value of man power in agriculture should be compared with the value of man product in other industry, and for man power the measure must be not the daily output for part-time employment, but the annual output, which is the necessary basis of the wage that pays living expenses for the year. It is the coal the miner mines in a year that benefits the coal consumer and supports the mine worker and his family.

The best war-time example of organized industry was the shipbuilding industry as it was federalized. The supplies of both labor and material were diverted into well organized channels, a monopolistic programme with the fixed purpose of speeding to the limit the output of the ships needed by the nation. In other work, too, putting industry on a war basis meant replacing the less essential product with something directly or indirectly necessary for the conduct of the war. The action of the War Industries Board in standardizing various articles, whether metal beds or ladies' shoes or automobile tires or men's hats or wagon chains, was a long step in conservation of material and labor used in manufacture as well as of the capital locked up in the stock in trade in merchandizing. Too much liberty of demand and supply had resulted simply in bondage to the whims of customers. Cutting out the less essential is another habit of thrift that should have been retained after the coming of peace; waste cannot be afforded even if we have won the war.

In the organization of industry for economic defense efficiency must be studied in all its bearings. In *Eclipse*

or Empire? an appeal is made to the British nation to become awake to its industrial needs, and American efficiency is held up as the model, in superiority of business organization, larger use of machinery, and no restrictions of output, making larger wages possible on products which compete freely in neutral markets and even in Great Britain. This tribute to American success simply emphasizes the fact that in industry low-cost production is not inconsistent with large profits to capital and high wages to labor, and the naïve statement of a Government price-fixing board that profits are "necessarily great in the case of low-cost mills" is a similar recognition of the real service rendered by efficient management. Profit is thus not only the incentive to efficiency but its measure and test. Take away profit and its stimulus to personal initiative and responsibility and the State can substitute only an impersonal and bureaucratic control. Whether it is coal or iron or copper, compare the annual output of the American workman with the product of his British or French or German competitor and the result of the American system stands out. The larger the average output of the individual, the larger the margin above a minimum wage, and this margin is the factor of industrial safety — a safety which concerns in varying degree every member of the community. Price to the consumer rather than cost to the producer has been too much in the mind of the American public; the gospel of competition and the dogma of anti-combination have been the false teachings that have led the people astray in their wanderings in the desert. Public control of large industrial units, not their disintegration, should be the policy of our economic leaders if the land of promise is to be occupied by the chosen people of this Twentieth Century.

The largest use of mineral resources for the general welfare in reality involves an industry so complex in organization that it becomes difficult to place the credit for largest service. The giving of value to the mineral is well distributed all along the route from mine to market. The iron ore beneath a Minnesota swamp steadily takes on value as it is raised to the surface, hauled down to Duluth, loaded on an ore steamer, and carried to Cleveland and thence by rail to Pittsburgh, where it meets the coke from the Connellsville ovens. Even there at the Homestead plant the value of the red dirt is only potential, for it must pass through the stages of molten iron, steel ingot, and plate and go to the fabricating mill and thence to the great Hog Island shipyard before its purpose in the world's life can be clearly seen and its true value estimated. From Minnesota mine to Pennsylvania shipyard the commodity market price has changed from $5.60 for the ore containing the ton of iron to $70 for the ton of ship plates, and to attain this increase in value railroad hands and ship crews, furnace and rolling-mill workers have all added their labor to that of the mine worker.

In a large way, then, the possession of rich resources of raw materials is only a starting point in national greatness; there must be industrial skill and transportation efficiency all the way from the mine to the market place where the highly finished product reaches the consumer. With this ultimate consumer use begins and real value can be measured; and the greater the need for that product and the larger that market place — even world-wide perhaps, the larger dividends will the favored nation earn and receive from its natural wealth. Thus through use only do resources profit a nation.

American industry is courageous; it revives the

pioneer spirit which is inbred in American character. And the industry of our country has shown that it is adaptable; it even thrives on changing conditions. The war-time test was met by an industrial expansion which can reasonably be regarded as a promise of still greater success in the future. Yet there is always some cause to fear and reason to avoid the industrial inflation that can bring disaster, and surely a nation whose only thought is exploitation of its resources lives in a fool's paradise.

While we are making the world democratic, we must not make America Germanic. Our country can well beware of overproduction, that megalomania which led German industry to organize itself into a kind of Empire-wide trust to storm and capture the world market. The economic policy of Germany largely determined its political policy, and with the militaristic spirit of conquest the campaign for markets did not stop at costs; in commerce as in war the German leaders seemed to set no limit to their sacrifices of others. The dilemma that overproductive German industry finally faced, as has been pointed out by Henri Hauser, was "Ruin or war, which is again ruin."

The German economic policy of organized industry — a "get-rich-quick" plan on an imperial scale — however efficient and scientific in appearance, presents much that should be avoided in any projected national policy. Germany was not self-sufficient, but in reality was so dependent upon outside markets wherein both to sell manufactures and buy raw materials that the *über Alles* policy became an economic necessity. So it was that the "industrial penetration" by the Germans had extended not only into Russia on the east and throughout France on the west, but even across the Atlantic on a

scale not generally known before the Alien Property Custodian began to unearth it. To obtain an outlet for overproduction the German cartel provided for co-operative selling under most favorable conditions of marketing. Essential preliminaries to such economy in action are standardization of product and submission by producer to discipline; it amounts to a blind pool of output, perhaps most closely approached by our own war-time control of the coal industry.

Germany's lack of internal balance is shown by the fact that her exports of industrial products exceeded her home consumption, and yet her imports of food and raw materials exceeded her exports. Except for coal, German mines failed to keep pace with German furnaces and factories. Thus the blockade that threw the Allied nations on their own resources at the same time proved how artificial was the foundation on which German industry rested. The German economists seemed to overlook the advantage of a home market and failed to see that increased consumption is something to be desired on its own account, as an expression of higher standards of living and as the connecting link between production and welfare.

Undoubtedly the full development of a nation's domestic industry requires an adequate merchant marine. We have to look back a generation or more to a day when the United States owned so large a percentage of the world's shipping as in 1917 and our shipping programme is even now only in its first act. America's new merchant marine means the removal of a great handicap. Now that peace conditions are established American goods will be reaching the South American markets in increasing amounts, and some of these neighbor countries under war conditions have already accumulated

trade balances so large as to make them inviting markets for our producers.

World commerce offers these larger opportunities to American industry, yet other countries have also expanded their manufacturing capacity, which now may be turned from munitions to other mill products, from swords to plowshares, from explosives to dyestuffs. However, the peaceful arts the world over require raw materials, and America can have the choice to some degree whether she exports the crude metals or the manufactures that represent both labor and material resources.

The economic policy that in the past transformed American infant industries into giant organizations which supplied Democracy with its munitions of war may find new application in the period now before us. In our organization of industry a certain amount of support may seem demanded for the large group of "war babies" whose rapid growth in the feverish years of war may tend to make the period of readjustment even harder for them to live through. It is, of course, a debatable economic question whether all of these new industries should survive; American experience has shown that some industries soon outgrow the need of governmental fostering, others never grow up. It is therefore, a matter of broad economic consideration rather than of narrow political expediency to determine for what period each domestic industry deserves protection in the home market, and to what extent it is of national benefit that this or that new industry be continued when foreign supplies are again available.[2] It is a national and not a local issue whether Georgia pyrite and Virginia manga-

[2] These and allied questions are discussed in this series in W. S. Culbertson, *Commercial Policy in War Time and After.*

nese and Nebraska potash are to replace Spanish and Brazilian ores and Alsatian salts under peace conditions of world trade.

In terms of mineral strategy, exchange of commodities with foreign countries strengthens our position of industrial prosperity if we export finished rather than crude products and import raw materials rather than manufactures. Industrial independence is the goal toward which a nation should face, but not a goal which it should have either the intention or the desire to attain. The industrial independence of the small community of a century ago has given way to the system under which your dinner table may represent tribute from several continents. Even in a country so diversified in natural bounties as ours, domestic production of everything we consume is not desirable or profitable. Exchange of commodities with foreign countries becomes necessary, for instance, just as soon as America can mine and smelt copper or produce and refine petroleum more cheaply than it can grow tea, sheep, or cattle. Then the home market for cheap meat and wool and tea necessitates a foreign market for our copper and oil. And in the search for foreign markets the American capitalist and the American engineer need to be our pioneers by helping the citizens of other countries to develop their own resources and to establish industries that will support large communities of consumers whose higher standards of living will bind them in every way, economic as well as social, closer to our own people. Commerce that brings to our home markets the coffee and cacao and rubber raised by our neighbors in the South or the tea and silk of the Orient in exchange for our sewing machines and typewriters and harvesters is commerce that makes of the world one community in which there can be

that sharing of opportunity to live well which is the essence of democracy.

There is spreading over the world a clearer perception of what the world needs. In the midst of the shadows of war even a German newspaper, the Berlin *Tageblatt,* admitted that a State different in its very makeup from the rest of the world cannot enjoy the confidence of its neighbors. The whole world is coming to adopt those ideals of which President Wilson is the chief exponent — a partnership of democratic nations in the steadfast concert for peace.

Democracy should, however, begin at home, and for this reason the material resources of America deserve recognition as a large factor in making our nation truly democratic and thus better fitted for world leadership. "America is the ultimate citadel of liberty." So America's contribution to the establishment and maintenance of peace is made not simply at the table of the Peace Conference or even in our own halls of Congress, but wherever decisions are made in the conduct of everyday business by citizens in every walk of life. No nation can long remain more altruistic than its citizens.

Industrialism and imperialism may mix to yield efficiency of a kind, but industry and democracy are capable of uniting in a different way. Here the partnership must be on more equitable terms; the profits must be more widely distributed; success must be measured by a different yardstick. Yet we cannot overlook the economic strength that has grown out of Prussian discipline in industry; both on the battlefront in France and in the industrial centers at home our citizens have come to realize the advantages of united action. The

dependence of our soldiers overseas upon our civilians at home; the dependence of the munition worker in Connecticut upon the coal miner in Pennsylvania, the zinc miner in Missouri, and the copper miner in Arizona; and the dependence of all these miners in turn upon the farmers and ranchers the country over — all this interlocking of wheels within wheels in the industrial machine became most obvious under war-time stress, and the workers were drawn together by their common service.

In a democracy every man has the right to reason why; the thinking workman came to see more clearly his part in carrying on the war, and he will see more clearly also his share in the nation's industrial responsibilities now it is again at peace. The arm of the miner of manganese in Arkansas became stronger when he learned to realize that the ore he sent up to the light of day was essential to the operation of the great steel plants in Pittsburgh, and that through his aid we had to ship less manganese ore from Brazil, so that by speeding up the mine in which he worked he helped to make another ship available to carry flour to France where perhaps his son was in a front-line trench. Edward Everett Hale saw the advantage of making "men understand that civilization consists in having workmen who use their brains instead of laborers who use their bodies." Does it not follow that democracy accomplishes its full purpose only when all workers, whether they use brains or bodies or both, realize the part they are contributing to the whole?

The doctrine of "something for nothing," the keynote of bolshevism, is false, and it is not the doctrine to fit American industry for true democracy. Service sharing is the preliminary for profit sharing. The British economists point to the larger productivity and

higher wages in America not as something to be offset or crushed by unfair competition, but as something to be translated into British practice in the workshops of England and the mines of Wales. To build up American industry, then, as a structure safely founded upon abundant resources and wisely planned to serve American citizenship, is in reality not wholly a self-centered enterprise, but one which reaches far out in real service to other nations. Just as the prosperity of our neighbors on the same street benefits the whole community, so the largest development of America on right lines makes for increased happiness the world over.

The world will be made over — in fact, it is being made over. The close union of so many strong nations fighting for an ideal became prophetic of new international relations when peace is fully established, and when we saw the peoples of England and France eating bread made from the wheat saved in the American homes, we faced a new vista of world citizenship. Because democracy comes nearest to spelling humanity it is not too idealistic to be practical.

Yesterday the Allied nations were fighting to make the world democratic; tomorrow they must carry out a programme to keep the world safe for democracy. Plans for universal and perpetual peace have been debated for centuries, but too often the peace that has been agreed upon has been merely an armed truce. So the ideal of world-wide democracy will not be attained if in the peace adopted a trace remains of the German policy of taking over the rules of war into the economic competition for markets with the purpose of crushing to death the industrial rivalry of other nations. Recent revelations of the German militaristic plans for trade aggression under cover of peace lay bare the dangers of

an inconclusive peace. The issue in simple terms is: What kind of a world do we wish to live in under conditions of peace?

As citizens our personal liberty is qualified by the rights of others, yet we do not thereby sacrifice individuality; so world citizenship or internationalism does not mean the giving up of nationalism; it means only surrender of whatever in nationalism may by agression injure other nations. Democracy within the State finds its logical counterpart in internationalism; we cannot justly claim equal rights among ourselves and oppose equal rights among nations. The Golden Rule has application in world economics.

Henri Hauser in his analysis of *Germany's Commercial Grip on the World* uses the suggestive phrase, "examination of the economic conscience." It may be charged that corporations have no souls, but industry must have a conscience — intelligent standards of action, clear aims for its activity, and a firm purpose to conform with its standards and to carry out its aims. What shall it profit an industry based on natural resources and looking for foreign as well as home markets if it gain the whole world yet lose its own soul? Production that grinds its labor and exhausts the nation's material resources may gain markets and yet do business at a loss. National values are to be reckoned in the essentials of life as well as in dollars. Our own Declaration of Independence put some emphasis upon the pursuit of happiness.

Commerce does not bring peace to the world if trade is too competitive. Competition may be preferable to monopoly, but best of all is the fair rivalry for markets, in which the best goods produced at the lowest costs win their way simply through the service rendered to

the consumer. The spirit of the world trade can be like the English spirit of sportsmanship. Competition between nation and nation may be as fair in method and principle as competition between two merchants in the same block or between two manufacturers on the same river. Judicial decisions and legislative enactments have defined more and more exactly what constitutes unfair tactics in interstate business, so that American citizens can bring to the consideration of international trade some comprehension of what fair competition means.[3]

Economic retaliation and the Golden Rule are policies diametrically opposed, but reciprocity and equality of treatment are of practical value in international economics. The difficulties and the disadvantages that have been found to attend trade boycott and embargo in time of war ought alone to be enough to dissuade the world from the continuance of any similar policy now peace is declared. Every nation likes to buy in the cheapest market and to sell in the dearest market; in fact, the mere thought of any restrictions upon such freedom of action runs counter to the very idea of trade. The open door belongs to an era of peace.

Adoption of the open-door policy however, need not involve throwing away the key. True strategy in industry and commerce must be directed toward preserving the home means of defense. If the foreign competitor invades a market at a heavy tax on his own home consumer, surely it is wise to close our market against him by legislation, even if that action shall for a time raise the price. It may be good international policy to buy the lowest-cost product, whether of home or foreign origin, but a low price which is below the cost is apt to

[3] On the subject of unfair practices in international commerce see W. S. Culbertson, *op. cit.*

be only a bait that conceals a hook. "Dumping" is plainly opposed to the conservation both of the world's resources and of the invaded country's industry, and legislation against this uneconomic practice, raised to the *n*th power by Germany, is well warranted both internationally and nationally.

The policy to live and let live may be only a partial expression of the Golden Rule, but it surely expresses industrial peace rather than industrial warfare. America can afford to be as idealistic in planning for the future as in fighting in the past. Germany thinks in terms of unfair trade practices because she is weak in resources; America's line of economic defence is strong even against unfair competition because of her unparalleled strength in mineral reserves. If it were possible to draw up a statement of these assets in which the mineral fuels, water power, ores of the essential metals, raw materials for the chemical industry, and all the other minerals that are so necessary to modern civilization were expressed in some common denominator and the grand total compared with a similar valuation for any other nation, be it Germany, France, Russia, or the British Empire, the statistical exhibit would show America's possibilities of industrial leadership more conclusively than any series of adjectives. Yet all this heritage is, as Secretary Lane has stated it, simply a challenge to us to prove our capacity to hold it and bring out of it what the world needs.

In seeking this largest and best use we must look far ahead. Professor Ely's economic generalization sums up both the law and prophets: "Every step forward in civilization means increased regard for the interests of the future." Neither these resources of America nor the markets of the world need to be exploited to bring last-

ing prosperity to our citizens; we need wage no offensive campaign adopting Prussian methods. As an economic defence safeguarding the future, the strategic value of America's wealth of mineral resources will be determined by the scientific efficiency of American engineering, the highly productive capacity of American labor, and the far-seeing conservatism of American democracy.

APPENDIX

WAR-TIME CONTROL OF MINERALS

Legislation in direct recognition of the war-time *rôle* of minerals as essential raw material was limited to two acts. The first of these was the Food and Fuel Control Act of August 10, 1917, which formed the legislative basis for the control of fuels by the United States Fuel Administration, established by executive order of the President dated August 23, 1917. The operations of the Fuel Administration are described in Chapter III. The following is the text of the Food and Fuel Control Act, with the exception of Sections 11, 14, 15, and 16, which relate to food products exclusively:

FOOD AND FUEL CONTROL ACT

An Act To provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of food products and fuel.

Be it enacted, etc., That by reason of the existence of a state of war, it is essential to the national security and defense, for the successful prosecution of the war, and for the support and maintenance of the Army and Navy, to assure an adequate supply and equitable distribution, and to facilitate the movement, of foods, feeds, fuel including fuel oil and natural gas, and fertilizer and fertilizer ingredients, tools, utensils, implements, machinery, and equipment required for the actual production of foods, feeds, and fuel, hereafter in this Act called necessaries; to prevent, locally or generally, scarcity, monopolization, hoarding, injurious speculation, manipulations, and private controls, affecting such supply, distribution, and movement; and to establish and maintain governmental control of such necessaries during the war. For such purposes the instrumentalities, means, methods, powers, authorities, duties, obligations, and prohibitions hereinafter set forth are created, established, conferred, and prescribed. The President

is authorized to make such regulations and to issue such orders as are essential effectively to carry out the provisions of this Act.

SEC. 2. That in carrying out the purposes of this Act the President is authorized to enter into any voluntary arrangements or agreements, to create and use any agency or agencies, to accept the services of any person without compensation, to coöperate with any agency or person, to utilize any department or agency of the Government, and to coördinate their activities so as to avoid any preventable loss or duplication of effort or funds.

SEC. 3. That no person acting either as a voluntary or paid agent or employee of the United States in any capacity, including an advisory capacity, shall solicit, induce, or attempt to induce any person or officer authorized to execute or to direct the execution of contracts on behalf of the United States to make any contract or give any order for the furnishing to the United States of work, labor, or services, or of materials, supplies, or other property of any kind or character, if such agent or employee has any pecuniary interest in such contract or order, or if he or any firm of which he is a member, or corporation, joint-stock company, or association of which he is an officer or stockholder, or in the pecuniary profits of which he is directly or indirectly interested, shall be a party thereto. Nor shall any agent or employee make, or permit any committee or other body of which he is a member to make, or participate in making, any recommendation concerning such contract or order to any council, board, or commission of the United States, or any member or subordinate thereof, without making to the best of his knowledge and belief a full and complete disclosure in writing to such council, board, commission, or subordinate of any and every pecuniary interest which he may have in such contract or order and of his interest in any firm, corporation, company, or association being a party thereto. Nor shall he participate in the awarding of such contract or giving such order. Any willful violation of any of the provisions of this section shall be punishable by a fine of not more than $10,000, or by imprisonment of not more than five years, or both: *Provided,* That the provisions of this section shall not change, alter or repeal section forty-one of

chapter three hundred and twenty-one, Thirty-fifth Statutes at Large.

SEC. 4. That it is hereby made unlawful for any person willfully to destroy any necessaries for the purpose of enhancing the price or restricting the supply thereof; knowingly to commit waste or willfully to permit preventable deterioration of any necessaries in or in connection with their production, manufacture, or distribution; to hoard, as defined in section six of this Act, any necessaries; to monopolize or attempt to monopolize, either locally or generally, any necessaries; to engage in any discriminatory and unfair, or any deceptive or wasteful practice or device, or to make any unjust or unreasonable rate or charge, in handling or dealing in or with any necessaries; to conspire, combine, agree, or arrange with any other person, (*a*) to limit the facilities for transporting, producing, harvesting, manufacturing, supplying, storing, or dealing in any necessaries; (*b*) to restrict the supply of any necessaries; (*c*) to restrict distribution of any necessaries; (*d*) to prevent, limit, or lessen the manufacture or production of any necessaries in order to enhance the price thereof, or (*e*) to exact excessive prices for any necessaries; or to aid or abet the doing of any act made unlawful by this section.

SEC. 5. That, from time to time, whenever the President shall find it essential to license the importation, manufacture, storage, mining, or distribution of any necessaries, in order to carry into effect any of the purposes of this Act, and shall publicly so announce, no person shall, after a date fixed in the announcement, engage in or carry on any such business specified in the announcement of importation, manufacture, storage, mining, or distribution of any necessaries as set forth in such announcement, unless he shall secure and hold a license issued pursuant to this section. The President is authorized to issue such licenses and to prescribe regulations for the issuance of licenses and requirements for systems of accounts and auditing of accounts to be kept by licensees, submission of reports by them, with or without oath or affirmation, and the entry and inspection by the President's duly authorized agents of the places of business of licensees. Whenever the President shall find that any storage charge, commission, profit, or practice of any licensee is unjust, or unreasonable,

or discriminatory and unfair, or wasteful, and shall order such licensee, within a reasonable time fixed in the order, to discontinue the same, unless such order, which shall recite the facts found, is revoked or suspended, such licensee shall, within the time prescribed in the order, discontinue such unjust, unreasonable, discriminatory and unfair storage charge, commission, profits, or practice. The President may, in lieu of any such unjust, unreasonable, discriminatory, and unfair storage charge, commission, profit, or practice, find what is a just, reasonable, nondiscriminatory and fair storage charge, commission, profit, or practice, and in any proceeding brought in any court such order of the President shall be *prima facie* evidence. Any person who, without a license issued pursuant to this section, or whose license shall have been revoked, knowingly engages in or carries on any business for which a license is required under this section, or willfully fails or refuses to discontinue any unjust, unreasonable, discriminatory and unfair storage charge, commission, profit, or practice, in accordance with the requirement of an order issued under this section, or any regulation prescribed under this section, shall upon conviction thereof, be punished by a fine not exceeding $5,000, or by imprisonment for not more than two years, or both: *Provided,* That this section shall not apply to any farmer, gardener, coöperative association of farmers or gardeners, including live-stock farmers, or other persons with respect to the products of any farm, garden, or other land owned, leased, or cultivated by him, nor to any retailer with respect to the retail business actually conducted by him nor to any common carrier, nor shall anything in this section be construed to authorize the fixing or imposition of a duty or tax upon any article imported into or exported from the United States or any State, Territory, or the District of Columbia: *Provided further,* That for the purposes of this Act a retailer shall be deemed to be a person, copartnership, firm, corporation, or association not engaging in the wholesale business whose gross sales do not exceed $100,000 per annum.

SEC. 6. That any person who willfully hoards any necessaries shall upon conviction thereof be fined not exceeding $5,000 or be imprisoned for not more than two years, or both. Necessaries shall be deemed to be hoarded within the meaning of this Act when either (*a*) held, contracted for, or arranged

for by any person in a quantity in excess of his reasonable requirements for use or consumption by himself and dependents for a reasonable time; (*b*) held, contracted for, or arranged for by any manufacturer, wholesaler, retailer, or other dealer in a quantity in excess of the reasonable requirements of his business for use or sale by him for a reasonable time, or reasonably required to furnish necessaries produced in surplus quantities seasonally throughout the period of scant or no production; or (*c*) withheld, whether by possession or under any contract or arrangement, from the market by any person for the purpose of unreasonably increasing or diminishing the price: *Provided,* That this section shall not include or relate to transactions on any exchange, board of trade, or similar institution or place of business as described in section thirteen of this Act that may be permitted by the President under the authority conferred upon him by said section thirteen: *Provided, however,* That any accumulating or withholding by any farmer or gardener, coöperative association of farmers or gardeners, including live-stock farmers, or any other person, of the products of any farm, garden, or other land owned, leased, or cultivated by him shall not be deemed to be hoarding within the meaning of this Act.

SEC. 7. That whenever any necessaries shall be hoarded as defined in section six they shall be liable to be proceeded against in any district court of the United States within the district where the same are found and seized by a process of libel for condemnation, and if such necessaries shall be adjudged to be hoarded they shall be disposed of by sale in such manner as to provide the most equitable distribution thereof as the court may direct, and the proceeds thereof, less the legal costs and charges, shall be paid to the party entitled thereto. The proceedings of such libel cases shall conform as near as may be to the proceedings in admiralty, except that either party may demand trial by jury of any issue of fact joined in any such case, and all such proceedings shall be at the suit of and in the name of the United States. It shall be the duty of the United States attorney for the proper district to institute and prosecute any such action upon presentation to him of satisfactory evidence to sustain the same.

SEC. 8. That any person who willfully destroys any necessaries for the purpose of enhancing the price or restricting the

supply thereof shall, upon conviction thereof, be fined not exceeding $5,000 or imprisoned for not more than two years, or both.

SEC. 9. That any person who conspires, combines, agrees, or arranges with any other person (*a*) to limit the facilities for transporting, producing, manufacturing, supplying, storing, or dealing in any necessaries; (*b*) to restrict the supply of any necessaries; (*c*) to restrict the distribution of any necessaries; (*d*) to prevent, limit, or lessen the manufacture or production of any necessaries in order to enhance the price thereof shall, upon conviction thereof be fined not exceeding $10,000 or be imprisoned for not more than two years, or both.

SEC. 10. That the President is authorized, from time to time, to requisition foods, feeds, fuels, and other supplies necessary to the support of the Army or the maintenance of the Navy, or any other public use connected with the common defense, and to requisition, or otherwise provide, storage facilities for such supplies; and he shall ascertain and pay a just compensation therefor. If the compensation so determined be not satisfactory to the person entitled to receive the same, such person shall be paid seventy-five per centum of the amount so determined by the President, and shall be entitled to sue the United States to recover such further sum as, added to said seventy-five per centum will make up such amount as will be just compensation for such necessaries or storage space, and jurisdiction is hereby conferred on the United States District Courts to hear and determine all such controversies: *Provided,* That nothing in this section, or in the section that follows, shall be construed to require any natural person to furnish to the Government any necessaries held by him and reasonably required for consumption or use by himself and dependents, nor shall any person, firm, corporation, or association be required to furnish to the Government any seed necessary for the seeding of land owned, leased, or cultivated by them.

. . . .

SEC. 12. That whenever the President shall find it necessary to secure an adequate supply of necessaries for the support of the Army or the maintenance of the Navy, or for any other public use connected with the common defense, he is au-

thorized to requisition and take over, for use or operation by the Government, any factory, packing house, oil pipe line, mine, or other plant, or any part thereof, in or through which any necessaries are or may be manufactured, produced, prepared, or mined, and to operate the same. Whenever the President shall determine that the further use or operation by the Government of any such factory, mine, or plant, or part thereof, is not essential for the national security or defense, the same shall be restored to the person entitled to the possession thereof. The United States shall make just compensation, to be determined by the President, for the taking over, use, occupation, and operation by the Government of any such factory, mine, or plant, or part thereof. If the compensation so determined be unsatisfactory to the person entitled to receive the same, such person shall be paid seventy-five per centum of the amount so determined by the President, and shall be entitled to sue the United States to recover such further sum as, added to said seventy-five per centum, will make up such amount as will be just compensation, in the manner provided by section twenty-four, paragraph twenty, and section one hundred and forty-five of the Judicial Code. The President is authorized to prescribe such regulations as he may deem essential for carrying out the purposes of this section, including the operation of any such factory, mine, or plant, or part thereof, the purchase, sale, or other disposition of articles used, manufactured, produced, prepared, or mined therein, and the employment, control, and compensation of employees. Any moneys received by the United States from or in connection with the use or operation of any such factory, mine, or plant, or part thereof, may, in the discretion of the President, be used as a revolving fund for the purpose of the continued use or operation of any such factory, mine, or plant, or part thereof, and the accounts of each such factory, mine, plant, or part thereof, shall be kept separate and distinct. Any balance of such moneys not used as part of such revolving fund shall be paid into the Treasury as miscellaneous receipts.

SEC. 13. That whenever the President finds it essential in order to prevent undue enhancement, depression, or fluctuation of prices of, or in order to prevent injurious speculation in, or in order to prevent unjust market manipulation or un-

fair and misleading market quotations of the prices of necessaries, hereafter in this section called evil practices, he is authorized to prescribe such regulations governing, or may either wholly or partly prohibit, operations, practices, and transactions at, on, in, or under the rules of any exchange, board of trade, or similar institution or place of business as he may find essential in order to prevent, correct, or remove such evil practices. Such regulations may require all persons coming within their provisions to keep such records and statements of account, and may require such persons to make such returns, verified under oath or otherwise, as will fully and correctly disclose all transactions at, in, or on, or under the rules of any such exchange, board of trade, or similar institution or place of business, including the making, execution, settlement, and fulfillment thereof. He may also require all persons acting in the capacity of a clearing house, clearing association, or similar institution, for the purpose of clearing, settling, or adjusting transactions at, in, or on, or under the rules of any such exchange, board of trade, or similar institution or place of business, to keep such records and to make such returns as will fully and correctly disclose all facts in their possession relating to such transactions, and he may appoint agents to conduct the investigations necessary to enforce the provisions of this section and all rules and regulations made by him in pursuance thereof, and may fix and pay the compensation of such agents. Any person who willfully violates any regulation made pursuant to this section, or who knowingly engages in any operation, practice, or transaction prohibited pursuant to this section, or who willfully aids or abets any such violation or any such prohibited operation, practice, or transaction, shall, upon conviction thereof, be punished by a fine not exceeding $10,000 or by imprisonment for not more than four years, or both.

. . . .

SEC. 17. That every person who willfully assaults, resists, impedes, or interferes with any officer, employee, or agent of the United States in the execution of any duty authorized to be performed by or pursuant to this Act shall upon conviction thereof be fined not exceeding $1,000 or be imprisoned for not more than one year, or both.

SEC. 18. That the sum of $2,500,000 is hereby appropriated,

out of any moneys in the Treasury not otherwise appropriated, to be available until June thirtieth, nineteen hundred and eighteen, for the payment of such rent, the expense, including postage, of such printing and publications, the purchase of such material and equipment, and the employment of such persons and means, in the city of Washington and elsewhere, as the President may deem essential.

SEC. 19. That for the purposes of this Act the sum of $150,000,000 is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, to be available during the time this Act is in effect: *Provided,* That no part of this appropriation shall be expended for the purposes described in the preceding section: *Provided further,* That itemized statements covering all purchases and disbursements under this and the preceding section shall be filed with the Secretary of the Senate and the Clerk of the House of Representatives on or before the twenty-fifth day of each month after the taking effect of this Act, covering the business of the preceding month, and said statements shall be subject to public inspection.

SEC. 20. That the employment of any person under the provisions of this Act shall not exempt any such person from military service under the provisions of the selective draft law approved May eighteenth, nineteen hundred and seventeen.

SEC. 21. The President shall cause a detailed report to be made to the Congress on the first day of January each year of all proceedings had under this Act during the year preceding. Such report shall, in addition to other matters, contain an account of all persons appointed or employed, the salary or compensation paid or allowed each, the aggregate amount of the different kinds of property purchased or requisitioned, the use and disposition made of such property, and a statement of all receipts, payments, and expenditures, together with a statement showing the general character, and estimated value of all property then on hand, and the aggregate amount and character of all claims against the United States growing out of this Act.

SEC. 22. That if any clause, sentence, paragraph, or part of this Act shall for any reason be adjudged by any court of competent jurisdiction to be invalid, such judgment shall not affect, impair, or invalidate the remainder thereof, but shall

be confined in its operation to the clause, sentence, paragraph, or part thereof, directly involved in the controversy in which such judgment shall have been rendered.

SEC. 23. That words used in this Act shall be construed to import the plural or the singular, as the case demands. The word "person," wherever used in this Act, shall include individuals, partnerships, associations, and corporations. When construing and enforcing the provisions of this Act, the act, omission, or failure of any official, agent, or other person acting for or employed by any partnership, association, or corporation within the scope of his employment or office shall, in every case, also be deemed the act, omissions, or failure of such partnership, association, or corporation as well as that of the person.

SEC. 24. That the provisions of this Act shall cease to be in effect when the existing state of war between the United States and Germany shall have terminated, and the fact and date of such termination shall be ascertained and proclaimed by the President; but the termination of this Act shall not affect any act done, or any right or obligation accruing or accrued, or any suit or proceeding had or commenced in any civil case before the said termination pursuant to this Act; but all rights and liabilities under this Act arising before its termination shall continue and may be enforced in the same manner as if the Act had not terminated. Any offense committed and all penalties, forfeitures, or liabilities incurred prior to such termination may be prosecuted or punished in the same manner and with the same effect as if this Act had not been terminated.

SEC. 25. That the President of the United States shall be, and he is hereby, authorized and empowered, whenever and wherever in his judgment necessary for the efficient prosecution of the war, to fix the price of coal and coke, wherever and whenever sold, either by producer or dealer, to establish rules for the regulation of and to regulate the method of production, sale, shipment, distribution, apportionment, or storage thereof among dealers and consumers, domestic or foreign; said authority and power may be exercised by him in each case through the agency of the Federal Trade Commission during the war or for such part of said time as in his judgment may be necessary.

That if, in the opinion of the President, any such producer

or dealer fails or neglects to conform to such prices or regulations, or to conduct his business efficiently under the regulations and control of the President as aforesaid, or conducts it in a manner prejudicial to the public interest, then the President is hereby authorized and empowered in every such case to requisition and take over the plant, business, and all appurtenances thereof belonging to such producer or dealer as a going concern, and to operate or cause the same to be operated in such manner and through such agency as he may direct during the period of the war or for such part of said time as in his judgment may be necessary.

That any producer or dealer whose plant, business, and appurtenances shall have been requisitioned or taken over by the President shall be paid a just compensation for the use thereof during the period that the same may be requisitioned or taken over as aforesaid, which compensation the President shall fix or cause to be fixed by the Federal Trade Commission.

That if the prices so fixed, or if, in the case of the taking over or requisitioning of the mines or business of any such producer or dealer the compensation therefor as determined by the provisions of this Act be not satisfactory to the person or persons entitled to receive the same, such person shall be paid seventy-five per centum of the amount so determined, and shall be entitled to sue the United States to recover such further sum as, added to said seventy-five per centum, will make up such amount as will be just compensation in the manner provided by section twenty-four, paragraph twenty, and section one hundred and forty-five of the Judicial Code.

While operating or causing to be operated any such plants or business, the President is authorized to prescribe such regulations as he may deem essential for the employment, control, and compensation of the employees necessary to conduct the same.

Or if the President of the United States shall be of the opinion that he can thereby better provide for the common defense, and whenever, in his judgment, it shall be necessary for the efficient prosecution of the war, then he is hereby authorized and empowered to require any or all producers of coal and coke, either in any special area or in any special coal fields, or in the entire United States, to sell their products only to the United States through an agency to be designated

by the President, such agency to regulate the resale of such coal and coke, and the prices thereof, and to establish rules for the regulation of and to regulate the methods of production, shipment, distribution, apportionment, or storage thereof among dealers and consumers, domestic or foreign, and to make payment of the purchase price thereof to the producers thereof, or to the person or persons legally entitled to said payment.

That within fifteen days after notice from the agency so designated to any producer of coal and coke that his, or its, output is to be so purchased by the United States as hereinbefore described, such producer shall cease shipments of said product upon his own account and shall transmit to such agency all orders received and unfilled or partially unfilled, showing the exact extent to which shipments have been made thereon, and thereafter all shipments shall be made only on authority of the agency designated by the President, and thereafter no such producer shall sell any of said products except to the United States through such agency, and the said agency alone is hereby authorized and empowered to purchase during the continuance of the requirement the output of such producers.

That the prices to be paid for such products so purchased shall be based upon a fair and just profit over and above the cost of production, including proper maintenance and depletion charges, the reasonableness of such profits and cost of production to be determined by the Federal Trade Commission, and if the prices fixed by the said commission of any such product purchased by the United States as hereinbefore described be unsatisfactory to the person or persons entitled to the same, such person or persons shall be paid seventy-five per centum of the amount so determined, and shall be entitled to sue the United States to recover such further sum as, added to said seventy-five per centum, will make up such amount as will be just compensation in the manner provided by section twenty-four, paragraph twenty, and section one hundred and forty-five of the Judicial Code.

All such products so sold to the United States shall be sold by the United States at such uniform prices, quality considered, as may be practicable and as may be determined by said agency to be just and fair.

Any moneys received by the United States for the sale of any such coal and coke may, in the discretion of the President, be used as a revolving fund for further carrying out the purposes of this section. Any moneys not so used shall be covered into the Treasury as miscellaneous receipts.

That when directed by the President, the Federal Trade Commission is hereby required to proceed to make full inquiry, giving such notice as it may deem practicable, into the cost of producing under reasonably efficient management at the various places of production the following commodities, to wit, coal and coke.

The books, correspondence, records, and papers in any way referring to transactions of any kind relating to the mining, production, sale, or distribution of all mine operators or other persons whose coal and coke have or may become subject to this section, and the books, correspondence, records, and papers of any person applying for the purchase of coal and coke from the United States shall at all times be subject to inspection by the said agency, and such person or persons shall promptly furnish said agency any data or information relating to the business of such person or persons which said agency may call for, and said agency is hereby authorized to procure the information in reference to the business of such coal-mine operators and producers of coke and customers therefor in the manner provided for in sections six and nine of the Act of Congress approved September twenty-sixth, nineteen hundred and fourteen, entitled "An Act to create a Federal Trade Commission, to define its powers and duties, and for other purposes," and said agency is hereby authorized and empowered to exercise all the powers granted to the Federal Trade Commission by said Act for the carrying out of the purposes of this section.

Having completed its inquiry respecting any commodity in any locality, it shall, if the President has decided to fix the prices at which any such commodity shall be sold by producers and dealers generally, fix and publish maximum prices for both producers of and dealers in any such commodity, which maximum prices shall be observed by all producers and dealers until further action thereon is taken by the commission.

In fixing maximum prices for producers the commission shall allow the cost of production, including the expense of

operation, maintenance, depreciation, and depletion, and shall add thereto a just and reasonable profit.

In fixing such prices for dealers, the commission shall allow the cost to the dealer and shall add thereto a just and reasonable sum for his profit in the transaction.

The maximum prices so fixed and published shall not be construed as invalidating any contract in which prices are fixed, made in good faith, prior to the establishment and publication of maximum prices by the commission.

Whoever shall, with knowledge that the prices of any such commodity have been fixed as herein provided, ask, demand, or receive a higher price, or whoever shall, with knowledge that the regulations have been prescribed as herein provided, violate or refuse to conform to any of the same, shall, upon conviction, be punished by fine of not more than $5,000, or by imprisonment for not more than two years, or both. Each independent transaction shall constitute a separate offense.

Nothing in this section shall be construed as restricting or modifying in any manner the right the Government of the United States may have in its own behalf or in behalf of any other Government at war with Germany to purchase, requisition, or take over any such commodities for the equipment, maintenance, or support of armed forces at any price or upon any terms that may be agreed upon or otherwise lawfully determined.

SEC. 26. That any person carrying on or employed in commerce among the several States, or with foreign nations, or with or in the Territories or other possessions of the United States in any article suitable for human food, fuel, or other necessaries of life, who, either in his individual capacity or as an officer, agent, or employee of a corporation or member of a partnership carrying on or employed in such trade, shall store, acquire, or hold, or who shall destroy or make away with any such article for the purpose of limiting the supply thereof to the public or affecting the market price thereof in such commerce, whether temporarily or otherwise, shall be deemed guilty of a felony and, upon conviction thereof, shall be punished by a fine of not more than $5,000 or by imprisonment for not more than two years, or both: *Provided*, That any storing or holding by any farmer, gardener, or other

person of the products of any farm, garden, or other land cultivated by him shall not be deemed to be a storing or holding within the meaning of this Act: *Provided further,* That farmers and fruit growers, coöperative and other exchanges, or societies of a similar character shall not be included within the provisions of this section: *Provided further,* That this section shall not be construed to prohibit the holding or accumulating of any such article by any such person in a quantity not in excess of the reasonable requirements of his business for a reasonable time or in a quantity reasonably required to furnish said articles produced in surplus quantities seasonally throughout the period of scant or no production. Nothing contained in this section shall be construed to repeal the Act entitled "An Act to protect trade and commerce against unlawful restraints and monopolies," approved July second, eighteen hundred and ninety, commonly known as the Sherman Antitrust Act.

The need of emergency measures to promote the production of certain minor minerals which had acquired major importance was early seen, and on March 26, 1918, the House Committee on Mines and Mining began public consideration of a proposed Mineral Control bill by hearing the Secretary of the Interior and other Government officials in its behalf. The purpose of this bill was to speed up production of some two score minerals and metals. These were described in the caption of the measure as having "formerly been largely imported or of which there is or may be an inadequate supply." As has been pointed out in Chapter II, the shipping crisis forced a greater dependence upon domestic resources, and the problem of balancing production and consumption seemed to require Federal stimulation of production and control of consumption, not by an interference with industry but as a support.

The bill was passed by the House of Representatives on April 30, and two days later its consideration was begun by the Senate Committee on Mines and Mining. As passed by the Senate and approved by the President

October 5, 1918, the Mineral Control Act provided authority to contract for the production of needed supplies and to control the distribution of these necessaries. The text of the law is as follows:

Mineral Control Act

An Act To provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of those ores, metals, and minerals which have formerly been largely imported, or of which there is or may be an inadequate supply.

Be it enacted, etc., That by reason of the existence of a state of war, it is essential to the national security and defense, and to the successful prosecution of the war, and for the support and maintenance of the Army and Navy, to provide for an adequate and increased supply, to facilitate the production, and to provide for an equitable, economical, and better distribution of the following-named mineral substances and ores, minerals, intermediate metallurgical products, metals, alloys, and chemical compounds thereof, to wit: Antimony, arsenic, ball clay, bismuth, bromine, cerium, chalk, chromium, cobalt, corundum, emery, fluorspar, ferrosilicon, fullers' earth, graphite, grinding pebbles, iridium, kaolin, magnesite, manganese, mercury, mica, molybdenum, osmium, sodium, platinum, palladium, paper clay, phosphorus, potassium, pyrites, radium, sulphur, thorium, tin, titanium, tungsten, uranium, vanadium, and zirconium, as the President may, from time to time, determine to be necessary for the purposes aforesaid, and as to which there is at the time of such determination, a present or prospective inadequacy of supply. The aforesaid substances mentioned in any such determination are hereinafter referred to as necessaries.

Sec. 2. That the President is authorized from time to time to purchase such necessaries and to enter into, to accept, to transfer, and to assign contracts for the production or purchase of same, to provide storage facilities for and store the same, to provide or improve transportation facilities, and to use, distribute, or allocate said necessaries, or to sell the same at reasonable prices, but such sales made during the war shall not be at a price less than the purchase or cost of production thereof: *Provided,* That no such contract of purchase shall

cover a period longer than two years after the termination of the war.

The President is further authorized, upon finding that importation into the United States of any of the necessaries covered by this Act is likely to result in a loss to the United States on any necessaries which it may have acquired hereunder, to ascertain, fix, and proclaim such rate of duty upon such imported necessaries as shall be sufficient to adequately protect the United States from any such loss.

The funds provided by section six hereof shall be used in carrying out the powers granted by this section, and all moneys received by the United States from or in connection with the disposal of such necessaries, shall be used as a revolving fund for further carrying out the purposes of this Act. Any balance of such moneys remaining when the object of this Act has been accomplished, shall, as collected, received, and on hand and available, be covered into the Treasury as miscellaneous receipts.

SEC. 3. That the President is authorized to requisition and take over any of said necessaries and to use, distribute, allocate, or sell the same; and also to requisition and take over any undeveloped or insufficiently developed or operated idle land, deposit, or mine, and any idle or partially operated smelter, or plant, or part thereof, producing or, in his judgment, capable of producing said necessaries, or either of them, and to develop and operate such mine or deposit or such smelter or plant, either through the agencies hereinafter mentioned, or under lease or royalty agreement, or in any other manner, and to store, use, distribute, allocate, or sell the products thereof: *Provided,* That no ores or metals, the principal money value of which consists in metals or minerals other than those specifically enumerated in section one hereof, shall be subject to requisition under the provisions of this Act. Whenever the President shall determine that the further use or operation by the Government of any such land, deposit, mine, smelter, or plant, or part thereof, so acquired, is no longer essential for the objects aforesaid, the same shall be returned to the person, firm, or corporation entitled thereto. The United States shall make just compensation, determined by the President, for the taking over, use, occupation, or operation by the

Government of any such necessaries, or any such land, deposit, mine, smelter, or plant, or part thereof. If the compensation so determined be unsatisfactory to the person, firm, or corporation entitled thereto, such person, firm, or corporation shall be paid seventy-five per centum of the amount so determined and shall be entitled to sue the United States to recover such further sum as added to said seventy-five per centum will make up such amount as will be just compensation, in the manner provided by section twenty-four paragraph twenty, and section one hundred and forty-five, of the Judicial Code.

The President is authorized to require statements and reports, to examine books and papers, and to prescribe such rules and regulations as he may deem appropriate for carrying out the purposes of this Act. The fund provided by section six hereof may be used in carrying out the purposes of this Act, and all moneys received by the United States from or in connection with the use, operation, or disposal of any such necessaries, land, deposit, mine, smelter, or plant, or part thereof, shall be used as a revolving fund for further carrying out the purposes of this Act. Any balance of such moneys remaining when the objects of this Act have been accomplished, shall, as collected, received, and on hand and available, be covered into the Treasury as miscellaneous receipts.

SEC. 4. That any person who shall neglect or refuse to comply with any order or requisition made by the President pursuant to the provisions of this Act, or who shall obstruct or attempt to obstruct the enforcement of or the compliance with any such requisition or order, or who shall violate any of the provisions of this Act, or any rule or regulation adopted hereunder, shall, upon conviction, be fined not exceeding $5,000, or be imprisoned for not more than two years, or both.

SEC. 5. That the sum of $500,000 is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, to be available until June thirtieth, nineteen hundred and nineteen, for the payment of all administrative expenses under this Act, including personal services, traveling and subsistence expenses, the payment of rent, the purchase of equipment, supplies, postage, printing, publications, and such other articles, both in the District of Columbia and elsewhere, as the President may deem essential and proper.

SEC. 6. That the sum of $50,000,000 is hereby appropriated, out of any moneys in the Treasury not otherwise appropriated, which, together with all moneys received from time to time under the provisions of this Act, all of which shall be credited to said appropriation, shall be used as a revolving fund for carrying out the objects of this Act, and for the purpose of making all payments and disbursements, including just compensation under section three, by this Act authorized: *Provided,* That no part of this appropriation shall be expended for the purposes described in the last preceding section: *Provided further,* That a detailed report of all operations under this Act, including all receipts and disbursements, shall be filed with the Secretary of the Senate and Clerk of the House of Representatives on or before the twenty-fifth day of each month, covering the preceding month's operation. Any balance of said revolving fund remaining when the objects of this Act have been accomplished, shall, as collected, received, and on hand and available, be covered into the Treasury as miscellaneous receipts.

SEC. 7. That the President is authorized to exercise each, every, or any power and authority hereby vested in him, and to expend the moneys herein appropriated or provided for, or any part or parts thereof, by and through such officer or officers, department or departments, board or boards, agent, agents, or agencies as he shall create or designate, from time to time, for the purpose. He may fix the reasonable compensation for the performance of such services, but no official or employee of the United States shall receive any additional compensation for such services except as now permitted by law: *Provided,* That no person employed under the provisions of this Act shall be paid any salary or compensation in excess of that paid for similar or like services rendered in executive departments of the Government.

SEC. 8. No person having a pecuniary interest in any transaction in pursuance of this Act shall have any official connection under this Act with such transaction. Any person violating this provision shall forfeit to the Government all proceeds which he shall have received from such transaction, and upon due conviction of such violation shall be fined not exceeding $10,000 or imprisoned not exceeding ten years.

SEC. 9. That the President is authorized, if in his judgment such action be necessary or useful for the objects of this Act, to form one or more corporations under the laws of any State, Territory, District, or possession of the United States, for the purpose of carrying out the powers or any of the powers hereby authorized. The capital stock of any such corporation shall be such as the President may determine, but the total capital stock for all corporations so formed shall not exceed in the aggregate the appropriation of $50,000,000, made by section six hereof. Said appropriation, or any part thereof, may be used by the President in subscribing on behalf of the United States, through such person or persons as he may designate, to the capital stock of such corporation or corporations, and the capital and assets of any such corporation or corporations, together with all additions thereto under sections two and three hereof, may be used in carrying out the objects of this Act. The directorate and organization of such corporation or corporations shall be such as the President may prescribe, and such corporation or corporations shall have all such charter powers as may be deemed necessary or desirable by the President to enable it or them to accomplish the objects of this Act. The capital stock of any such corporation or corporations shall be held and voted for the exclusive benefit of the United States, through such person or persons as the President may designate.

SEC. 10. Upon the proclamation of peace the President shall proceed as rapidly as possible to wind up and terminate all transactions under this Act, and to dispose as fast as practicable of all property acquired thereunder, and after said proclamation of peace no contracts shall be made, property acquired, or other transaction performed under this Act except such as shall be necessary for the purpose of this section and incidental thereto, and two years after such proclamation of peace this Act shall cease to have effect and all powers conferred thereby shall end: *Provided,* That the termination of this Act shall not prevent the subsequent collection of any moneys due the United States, nor shall it affect any act done or any right or obligation accrued or accruing, or any suit or proceeding had or commenced before such termination, but all such collections, rights, obligations, suits and proceedings shall continue as if this Act had not terminated, and any offense

committed or liability incurred prior thereto shall be prosecuted in the same manner and with the same punishment and effect as if this Act had not terminated.

SEC. 11. That employment under the provisions of this Act shall not exempt any person from military service under the provisions of the selective draft law approved May eighteenth, nineteen hundred and seventeen, or any Act amendatory thereto.

SEC. 12. That if any section or provision of this Act shall be declared invalid for any reason whatsoever, such invalidity shall not be construed to affect the validity of any other section or provision hereof.

By executive order issued on November 11, 1918, the Secretary of the Interior was directed to exercise the powers and authority given under the Act to the President, except those relating to duties upon imports. In view of the fact that the administration of the Mineral Control Act was not turned over to the Department of the Interior until the day of the signing of the armistice, it was too late to take action under it because there was no longer any necessity to stimulate production to meet war requirements.

As a result of the known shortage of many war minerals, of embargoes placed on their import, of the high prices prevailing, and of the anticipation of Government stimulation under this Act, the production of certain minerals had been largely increased and further preparations for increased production were being made. With the signing of the armistice, prices rapidly declined and there was practically no market for domestic ores. Many of the newly developed companies faced bankruptcy and the necessity of closing down their operations. The producers felt that the Government had been partly responsible for the stimulation of production and consequently took up with Congress the question of securing financial relief. As a result a section was

included in the Act for the settlement of informal army contracts[1] which authorized the examination of claims and settlement of net losses suffered by producers of manganese, chrome, pyrites, and tungsten when it was determined that such investment had been made as the result of the request of certain specified Government agencies. The text of Section 5 of this Act, which was approved on March 2, 1919, follows:

SEC. 5. That the Secretary of the Interior be, and he hereby is, authorized to adjust, liquidate, and pay such net losses as have been suffered by any person, firm, or corporation, by reason of producing or preparing to produce, either manganese, chrome, pyrites, or tungsten in compliance with the request or demand of the Department of the Interior, the War Industries Board, the War Trade Board, the Shipping Board, or the Emergency Fleet Corporation to supply the urgent needs of the Nation in the prosecution of the war; said minerals being enumerated in the Act of Congress approved October fifth, nineteen hundred and eighteen, entitled "An Act to provide further for the national security and defense by encouraging the production, conserving the supply, and controlling the distribution of those ores, metals, and minerals which have formerly been largely imported, or of which there is or may be an inadequate supply."

The said Secretary shall make such adjustments and payments in each case as he shall determine to be just and equitable; that the decision of said Secretary shall be conclusive and final, subject to the limitation hereinafter provided; that all payments and expenses incurred by said Secretary, including personal services, traveling and subsistence expenses, supplies, postage, printing, and all other expenses incident to the proper prosecution of this work, both in the District of Columbia and elsewhere, as the Secretary of the Interior may deem essential and proper, shall be paid from the funds appropriated by the said Act of October fifth, nineteen hundred and eighteen, and that said funds and appropriations shall continue to be available for said purpose until such time as the

[1] An Act To provide relief in cases of contracts connected with the prosecution of the war, and for other purposes.

have fully exercised the authority herein
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jurisdiction upon any court to entertain a suit against the United States: *Provided further,* That in determining the net losses of any claimant the Secretary of the Interior shall, among other things, take into consideration and charge to the claimant, the then market value of any ores or minerals on hand belonging to the claimant, and also the salvage or usable value of any machinery or other appliances which may be claimed was purchased to equip said mine for the purpose of complying with the request or demand of the agencies of the Government above mentioned in the manner aforesaid.

In order to carry out the provisions of this Act the Secretary of the Interior appointed a commission, known as the War Minerals Relief Commission, consisting of three members, John F. Shafroth, Martin D. Foster, and Philip N. Moore. The function of this Commission is to review the evidence submitted by the claimants and to secure such additional facts as are necessary through accounting and engineering examinations of books and properties. The field examinations are conducted by the Bureau of Mines. After reviewing all the facts a report is submitted to the Secretary of the Interior recommending the action to be taken. The Secretary of the Interior then makes a final award to the claimant.

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